U. S. Department of Agriculture
Agricultural Research Service
Entomology Research Branch
In cooperation with 16 cotton-growing States

CONFERENCE REPORT

ON

COTTON INSECT RESEARCH AND CONTROL

Memphis, Tenn., December 12-14, 1955

(Ninth Annual Report)

****

This is the ninth report to summarize results of conferences of State and Federal workers concerned with cotton insect research and control in the cotton-growing areas of the United States. The conferences were held at:

Stoneville, Miss., on November 17-19, 1947
Baton Rouge, La., on November 8-10, 1948
Jackson, Miss., on November 28-30, 1949
Memphis, Tenn., on December 4-6, 1950
Memphis, Tenn., on December 2-4, 1951
Memphis, Tenn., on December 7-9, 1952
Memphis, Tenn., on December 14-15, 1953
Dallas, Tex., on November 30-December 1, 1954
Memphis, Tenn., on December 12-14, 1955

Each report brings together the yearly results of research and experience in control of cotton insects. The purpose of these conferences is to review the research and experience of the previous years and to use them as a guide in the preparation of both State and Federal control recommendations for the following year. The Conference Reports are available, as long as the supply lasts, to entomologists and other research and extension workers, libraries, research agencies, the insecticide industry, and others interested in cotton production.

CONTENTS

Research and extension entomologists and associated technical workers from 16 cotton-growing States (Alabama, Arkansas, California, Florida, Georgia, Illinois, Kansas, Louisiana, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia), Puerto Rico, the United States Department of Agriculture, and the National Cotton Council of America participated in a conference at Memphis, Tenn., on December 12-14, 1955, to formulate a guiding statement for cotton-insect control recommendations in 1956 based on the research and experience of 1955 and previous years. Each section and sentence in this report was carefully considered and approved by the conferees. The conferees are listed on pages 66 to 70. Both cultural methods and the use of insecticides for controlling cotton pests are considered in this report.

Cultural control practices cannot be too strongly emphasized. Control of cotton insects with insecticides is really supplemental to good farm practices. Cultural control methods include early fall clean-up before frost where possible on farms infested with the boll weevil or pink bollworm, seed treatment, early planting, fertilization, use of proper cotton varieties, proper land use, and cultivation. Cultural measures depend upon the insects to be controlled and are influenced by climate, soil conditions, fertility, topography, and geographical location.

In addition to recommendations for the use of insecticides against cotton insects, this report presents information of value (1) to industry in planning production programs and (2) to State and Federal workers who cooperate with cotton growers in testing insecticides still in an experimental stage. It contains some suggestions as to research needs in developing more effective control programs. A general statement of plans is included, by which extension entomologists will aid in bringing to the attention of growers and all other interested groups the 1955 control recommendations for each State. Control recommendations are general and are not specifically fitted to local needs. In preparing recommendations for 1956 each State should adapt to its own conditions the information given in this summary.

No restrictions are placed on the duplication of this report in whole or in part. However if the report is not reprinted in its entirety, no less than a complete section relating to one material, or insect, and supplemental statements referred to therein should be copied. No portion of this report should be used for advertising purposes.

POLICY AND ETHICS

The chief purpose of the Cotton Insect Conference is to enable State and Federal entomologists to make readily available to each other information that may be useful in further research and extension work in cotton-insect control. This exchange of information makes mutual support possible.

While agreement on major recommendations may be expected, complete standardization is not possible. Details of recommendations must vary with requirements of the region or locality. Such variations are sometimes interpreted as disagreement among entomologists and can be a basis for confusion. To avoid this confusion, cotton growers should follow the advice of qualified entomologists in their respective States who are familiar with their local problems.

Successful procedures, equipment, and materials have been developed for control of insects and spider mites on cotton; however, research is continually improving upon existing practices, and attempting to anticipate and meet new problems. It is desirable that results of research should not be released, or made a basis for recommendations, until they have been made available to other entomologists working on cotton insects.

In making recommendations for the use of insecticides, entomologists should recognize their responsibility with regard to the hazards to public safety and other interests involved in their use.

Unfortunately, various so-called "remedies" for insect control have been put on the market through the years. Although some had slight value, most of them were less effective and more expensive than widely tested standard methods. Cotton growers are urged not to risk wasting money experimenting with unapproved devices, materials, or mixtures. They should not be persuaded to spend money in purchasing mixtures and machines that have little or no value in increasing yields or improving the quality of cotton.

Insecticide salesmen should recognize their responsibility to the cotton grower and industry in that they sell only approved materials and recommend treatment that will give the farmers the maximum return for their investment.

HAZARDS AND PRECAUTIONS IN THE USE OF INSECTICIDES

New synthetic organic insecticides and miticides have provided very effective pest control. Although many of them are not as toxic to man as some of those previously used, their utilization has sometimes brought on numerous problems. Therefore, they should be used with precaution and in the amounts and manner recommended.

Hazards

Insecticide injury to man may occur through oral or respiratory intake, or by skin absorption. Some solvents used in preparing solutions or emulsions are inflammable, and most of them are poisonous to some degree. In considering the hazards to man, it is necessary to distinguish between immediate hazards (acute toxicity) and accumulative hazards (chronic toxicity).

Research and experience have shown that the chlorinated hydrocarbons are reasonably safe at strengths normally applied to cotton. In concentrated form, however, they may cause acute poisoning. In addition, continued exposure to the lower concentrations may result in accumulation in the body with possible eventual tissue or organic injury.

Many of the phosphorus compounds--such as parathion, methyl parathion, Bayer 17147, EPN, TEPP, schradan, demeton, Diazinon, and American Cyanamid 3911--are extremely poisonous and must be handled with care at all times and in all forms. Their physiological activity in both insects and warm-blooded animals is primarily inhibition of the cholinesterase enzyme. Repeated exposure to them may reduce the cholinesterase level gradually to the point where symptoms may occur. Symptoms of poisoning include headache, pinpoint pupils, blurred vision, weakness, nausea, abdominal cramps, diarrhea, and tightness in the chest.

Precautions

It is not practicable to give all precautionary measures that should be taken when handling insecticides, but above all do not become careless even with materials of relatively low toxicity. Become acquainted with the hazards involved.

Oral intake.--Keep away from food all chemicals, including those in the vapor phase. Wash exposed portions of the body thoroughly before eating or drinking. Do not smoke or otherwise contaminate the mouth area before washing the face and hands.

Respiratory intake.--Wear approved respiratory devices when using highly toxic phosphorus compounds or heavy concentrations of other insecticides. Decontaminate the respirator between operations by washing and replacing felts and/or cartridges at recommended intervals of use. In June 1955 a circular entitled "Respiratory Devices for Protection Against Inhalation Hazards of Dusts, Mists, and Low Vapor Concentrations of Certain Insecticides" was made available by the Agricultural Research Service, U.S. Department of Agriculture.

Skin absorption.--Emulsifiable concentrates are particularly hazardous. Load and mix in the open. If the concentrate is spilled on the skin or clothing, wash the skin immediately and change to clean clothing. Bathe at the end of the work period. Wear natural-rubber gloves while handling highly toxic phosphorus compounds. Have at hand a change of clothing and soap and water in the field.

Additional precautions.--Regular users of phosphorus compounds should have their blood cholinesterase level checked before the start of a season's work and periodically thereafter. It is advisable to have on hand a small supply of 1/100-grain atropine tablets for emergency use as recommended by medical authorities in case of poisoning. Field workers should be kept out of treated fields for whatever time seems advisable.

Excess dust or spray materials should be buried, and empty insecticide containers should be burned or otherwise destroyed. Unused insecticides should be stored in places inaccessible to irresponsible persons or animals.

Residues on Plants

Spraying or dusting should be done under conditions and in a manner to avoid excessive drift to adjacent fields where animals are pastured or where food crops are being grown. Care in preventing drift is also essential because certain varieties of plants and kinds of crops may be injured by some insecticides.

In the development of new insecticides the possibility of deleterious residues remaining in cottonseed and seed products must be thoroughly investigated.

Cotton that has received applications late in the season of DDT and certain other persistent insecticides should not be grazed by dairy animals or meat animals soon to be slaughtered. Residues of calcium arsenate on cotton or in fields to which it has drifted are particularly hazardous to grazing animals.

Residues in Soils

The germination, rate of growth, and flavor of crops may be influenced by the insecticide or formulation used, the type of soil, the kind of plant, and/or the concentration of the residue in the soil. Apparently there is no immediate hazard to the growth of any crops when amounts and concentrations recommended for the control of cotton insects are followed. Off-flavor in root crops such as Irish potatoes, and in some areas peanuts, carrots, and tobacco, may result when grown in rotation with cotton that has received foliage applications of BHC.

Protection of Beneficial Insects and Wildlife

Predators and parasites play an important role in the control of insect pests on cotton. Because insecticides destroy beneficial as well as harmful insects, the control program should be devised to take maximum advantage of this natural control. It should be integrated to include chemical, natural, and cultural controls. The use of insecticides that are selective for the pest species concerned and of minimum detriment to the beneficial forms is desirable. Periodic inspections to determine populations of beneficial and injurious insects help eliminate unnecessary treatments.

Honey bees.--Insecticides applied to cotton may cause heavy losses of honey bees. Not only does cotton produce excellent honey, but many cotton growers are also growing legumes or other crops that require insect pollination. For the benefit of beekeepers, cotton growers, and agriculture in general, every effort should be made to protect pollinating insects.

The effect on honey bees should be considered whenever chemicals are applied. Any evaluation of the hazard of a particular insecticide should take into account its toxicity to the bees, the amount applied per acre, and the exposure. Calcium arsenate, which kills colonies outright, is the most dangerous insecticide in wide use on cotton. Organic insecticides usually kill only the field bees; they do not destroy the colony. However, some of these materials kill more bees than others. Parathion, EPN, malathion, BHC, lindane, and dieldrin are highly toxic to honey bees, and the bees should be moved before these materials are used. Heptachlor, chlordane, and probably aldrin may be used without hazard if precautions are employed as to timing, dosage, and application. Toxaphene and DDT may be used with relative safety. Methoxychlor, aramite, Ovex, demeton, and sulfur are of little hazard to bees.

To hold honey bee losses to a minimum, take the following precautions:

1. When possible, make applications during hours when bees are not visiting the cotton plants.
2. When practicable, use the insecticides least toxic to bees.
3. Avoid drift into bee yards and adjacent crops in bloom.
4. Beekeepers should keep informed of cotton-insect infestations and recommendations for their control. This knowledge will enable them to locate bee yards in the safest available places and to know where and when insecticide applications are likely to be made. They should also contact the cotton growers before the insect-control season begins, giving the location of their apiaries and requesting the growers' cooperation.
5. Cotton growers should notify beekeepers at least 48 hours before dusting or spraying, so that all possible protective measures can be taken.

6. County agents and other agricultural leaders should be given the exact location of apiaries. They could distribute such notification to beekeepers and recommend to cotton growers the materials least toxic to bees.

Honey bee losses can be reduced if better understanding and cooperation between beekeepers and cotton farmers is attained.

Fish and Wildlife:--Some insecticides useful in the cotton-pest control program are hazardous to fish and other wildlife. It is especially important to use minimum amounts where drift to ponds and streams is unavoidable. Runoff from treated fields should be diverted from fish ponds when possible. Where drift may create a problem, sprays are preferred to dusts. Every precaution should be taken to avoid the pollution of streams and farm ponds stocked with fish when excess spray or dust materials are being disposed of, or when equipment is being cleaned. When properly used there is little hazard to game animals and birds.

Additional Safeguards

Equipment used for applying 2,4-D and other hormone-type weed killers should not be used for applying insecticides because of danger of crop injury. Containers sometimes become contaminated with 2,4-D or 2,4,5-T on farms, and their re-use might prove very costly to the processor and to the farmer.

For stability in storage and to prevent breakdown of the emulsifiable concentrate formulations, metal containers should be lined with some material that will not react with the concentrate. It is not desirable to re-use metal containers for the packaging of emulsifiable concentrates. Used containers, especially 30- and 50-gallon drums, often have breaks in the linings. They are difficult to detect and will cause a breakdown of the formulation when it comes in contact with the metal.

FORMULATIONS

Dusts

Most organic insecticides and miticides are commonly used in dusts with talc, clay, calcium carbonate, pyrophyllite, or sulfur as the carriers. The value of formulations with proper dusting characteristics cannot be overemphasized. Erratic results and poor control are sometimes due to inferior formulations, although frequently poor results due to improper application or timing are blamed on formulations. Much progress has been made in regard to formulations, but it is in the interest of insecticide conservation and insect control to continue

to improve and standardize dust formulations. Some dusts containing high percentages of sulfur have undesirable dusting properties, but the incorporation of sulfur frequently helps to control spider mites.

Sprays

Cotton insect and spider mite control has been highly successful when sprays have been applied at rates ranging from 1 to 15 gallons per acre. Most of the organic-insecticide sprays used on cotton are made from emulsifiable concentrates. Occasional foliage injury has resulted from poorly formulated emulsions, or when the spray was improperly applied. Most oil solutions of insecticides cause foliage injury and therefore are not recommended. Emulsifiers and solvents should be tested for phytotoxicity before they are used in formulations. Phytotoxicity of emulsions may be aggravated by high temperatures, high concentrations, and dry winds.

Granules

The use of granular formulations of insecticides on inert carriers is established for white-fringed beetle control. Heptachlor in granular form has shown promise in some tests for control of the boll weevil during the growing season, and dieldrin and BHC granules for its control in hibernation. Further experimentation with different insecticides and formulations is needed.

Mixtures of insecticides and fertilizers are promising for control of soil insects. Such mixtures are being used for wireworm control on cotton in some areas. Mixtures of insecticides with sand, soil, or sawdust are also used for special purposes.

INSECTICIDE APPLICATIONS

Insecticides may be applied to cotton with either ground or aerial equipment. Regardless of equipment chosen, effective control is obtained only when applications are thorough and are properly timed. Improper and unnecessary applications often result in a pest complex that can cause greater damage to the cotton crop than the insect that originally required control.

Ground Application

Thorough distribution of dusts or sprays is essential for effective control of cotton pests. High-clearance rigs make possible efficient application in rank cotton without mechanical injury to plants.

Dusts.--For dust applications the nozzles should be adjusted to approximately 10 inches above the plants, with one nozzle over each row. Dusts should not be applied when the wind velocity exceeds 5 miles per hour. Dusts are usually applied at 10 to 15 pounds to the acre except in the Far West, where heavier dosages are required.

Sprays.--For spraying seedling cotton it is suggested that one nozzle per row be used, and as the cotton increases in size the number be increased to three. In rank growth as many as five or six nozzles may be used.

The nozzles should be adjusted to approximately 10 inches from the plants, and be capable of delivering from 1 to 8 gallons per acre, except in the Far West, where up to 15 gallons may be required. Sprays may be applied at wind velocities up to 15 miles per hour.

In most areas emulsifiable concentrates are diluted immediately before use with not to exceed an equal volume of water, and the emulsion is then added to the required volume of water. Some type of agitation, generally the by-pass flow, is necessary during the spray operation to insure a uniform mixture.

As a safety measure it is recommended that the spray boom be located behind the operator.

Aerial Application

In aerial applications certain general principles are applicable to either dusts or sprays. The swath width should be limited to the plane's wing span but not more than 40 feet. A method of flagging or marking should be used to secure proper distribution of the insecticide.

Dusts.--Properly formulated insecticides of free flowability should be used to obtain even distribution. Applications should not be made when the wind velocity exceeds 4 miles per hour.

Sprays.--Emulsifiable concentrates should be mixed with water to the desired dilution immediately before use. Planes should be equipped with standard nozzles or other atomizing devices that will produce droplets within the range of 100 to 300 microns. They should be equipped to deliver from 1 to 4 gallons of spray per acre depending on local conditions, except in the western areas where greater quantities may be required. Sprays may be applied at wind velocities up to 10 miles per hour.

Timing of Applications

With presently available insecticides successful control of cotton insects depends more on correct timing than on any other factor.

Consideration must be given to the overall population and stage of beneficial and harmful insects rather than to a single pest. The stage of growth of the cotton plant and expected yield are important.

Most insecticides kill predatory and parasitic insects as well as pest insects. Since the use of insecticides often induces outbreaks of bollworms, aphids, and spider mites, they should be applied only where and when needed.

Early-season applications should be made to control cutworms, beet armyworms, darkling ground beetles, grasshoppers, or aphids when these insects threaten to reduce a stand. Recommendations for early-season applications against thrips, boll weevils, fleahoppers, and plant bugs vary greatly from State to State. Differences in infestations of these insects as well as many other production factors make it undesirable to attempt to standardize recommendations for early-season control.

It is likewise generally recommended that suitable insecticides be applied to cotton during its maximum period of fruiting and maturing of the crop, if infestations threaten to reduce the yield, seriously affect quality, or delay maturity. Recommendations for insecticide treatments are similar throughout the Cotton Belt, but certain details differ from State to State, and often within the State.

RESISTANCE TO INSECTICIDES

The development of resistance of insects to insecticides is not new to the field of entomology, the first case being recorded as long ago as 1914, or earlier. The term "resistance" as used in this report denotes development of a tolerance to an insecticide which makes the insects more difficult to control, but does not necessarily imply complete resistance. It is well known that insect susceptibility to insecticides varies with the host or its stage of development or with the season of the year or other environmental factors. Such variations in susceptibility may be readily confused with hereditary resistance.

Laboratory tests in 1955 showed that boll weevils in certain areas of Louisiana had developed resistance to the following chlorinated hydrocarbons: BHC, dieldrin, endrin, heptachlor, and toxaphene. Many farmers in these areas failed to control weevils with chlorinated hydrocarbons even after increasing dosages and shortening intervals between applications. There were field-plot experiments in two of the areas in which these insecticides also failed to control boll weevils. From the laboratory tests, field experiments, and farmer failures it is concluded that boll weevils have developed degrees of resistance to the chlorinated hydrocarbons in localized areas in Louisiana.

In 1955 farmers failed to control boll weevils in localized areas in other States, particularly in the South Delta area of Mississippi and in a small section of southeastern Arkansas. Although resistance may be suspected in these areas, positive evidence of resistance does not exist as in Louisiana.

In most of the localities where farmer failures were common, weather conditions were extremely favorable for boll weevil multiplication and on the whole unfavorable for satisfactory application of insecticides. Owing to high fertilization of the land and excessive rainfall, cotton made a quick rank growth, which resulted in very little, if any, climatic control. With a relatively high initial infestation, this resulted in an unusually quick build-up to extremely high populations. Other factors known to reduce the effectiveness of most of the chlorinated hydrocarbons in killing boll weevils and which existed in these areas were frequent rains, high humidity, and low temperatures.

A combination of these factors and the known fact that weevils become more difficult to kill as the season progresses no doubt contributed to some of the failures.

The first suspicion of resistance of any cotton insect to the chlorinated hydrocarbons occurred in 1953. In some areas of Texas toxaphene at recommended dosages failed to give satisfactory control of the cotton leafworm. Laboratory tests confirmed these field observations. During the same year there were numerous complaints that BHC did not give adequate control of the cotton aphid and resistance was suspected, but laboratory and field experiments failed to support these suspicions. However, in 1955 failures adequately to control cotton aphids with BHC occurred in scattered areas of the central Cotton Belt and resistance is again suspected. This suspicion is supported by a limited number of laboratory and field-plot tests.

In portions of Arizona and southern California the salt-marsh caterpillar developed resistance to toxaphene, and DDT-toxaphene combinations.

In addition, resistance is suspected in the following insects to the designated insecticides: Cotton leaf perforator to recommended chlorinated hydrocarbons in restricted areas of the Imperial Valley of California; cabbage looper to DDT in many areas on several crops; southern garden leafhopper (Empoasca solana) to DDT in southern California; lygus bugs to toxaphene-DDT combination in the buckeye area of Arizona. Resistance of spider mites on cotton has not been convincingly demonstrated in the field, but resistance to parathion and certain other miticides is established in several other crops, particularly in greenhouses.

The problem of resistance is causing concern in all phases of applied entomology. The future of chemical control is not dark, however, for there is good evidence that not all insects are biochemically capable of developing resistance to a particular insecticide or group of insecticides. The big question is in which species will resistance appear next, for as yet there is no means of predicting resistance. The loss of resistance when it has reached a high level apparently will be a long, slow process. The following suggestions may help alleviate existing problems or delay the development of new ones. To lessen exposure of the insect population to insecticides, applications should be timed

and insecticides distributed so that control can be obtained with the fewest applications and the lowest total poundage. Insecticides are available which kill insects through entirely different physiological modes of action. It may be desirable to utilize effective insecticides with different modes of action.

The resistance problem emphasizes the importance of utilizing cultural control as much as possible in reducing populations of the boll weevil, the pink bollworm, and other insects where such methods are applicable.

Every advantage possible should be taken of biological control agents and when there is a choice, chemicals that are of minimum detriment to beneficial insects should be chosen.

INSECTICIDES AND MITICIDES

Insecticides and miticides useful for the control of cotton insects, including those still under investigation, are listed below. They are grouped according to general type and the stage of their development for practical use.

Chlorinated hydrocarbons	Organic phosphorus compounds	Others
Materials in Common Use or Promising for Widespread Acceptance		
Aldrin	Chlorthion	Aramite
BHC (benzene hexachloride)	Demeton	Calcium arsenate
Chlordane	Malathion	Sulfur
DDT	Methyl parathion	
Dieldrin	Parathion	
Endrin		
Heptachlor		
Lindane		
Toxaphene		
Promising Materials Recommended for Further Experimentation		
Rohm & Haas FW-293	American Cyanamid 3911	Dilan
	Bayer L 13/59	
	Bayer 17147	
	Chipman R-6199	
	DDVP	
	Diazinon	
	Hercules AC-528	
	Shell OS-2046	
Tested Materials of Limited Use		
Isodrin	EPN	Cryolite
Methoxychlor	Schradan	Lead arsenate
Ovex	TEPP	Nicotine
Strobane		Paris green
		Rotenone

Materials in Common Use or Promising for Widespread Acceptance

Aldrin

Aldrin will control the boll weevil, thrips, the cotton fleahopper, the tarnished plant bug, the rapid plant bug, grasshoppers, the fall armyworm, and lygus bugs. It will not control the bollworm, the pink bollworm, the yellow-striped armyworm, the cotton leafworm, the garden webworm, the cotton aphid, certain species of cutworms and most other lepidopterous larvae, or spider mites. The use of aldrin and mixtures of aldrin and DDT may result in increased populations of aphids and spider mites. For boll weevils, aldrin should be applied at the rate of 0.25 to 0.75 pound per acre, and when bollworms are a problem 0.5 to 1 pound of DDT should be added. It is effective in a dust or spray.

Aldrin is toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Aramite

Aramite will control spider mites when applied at 0.33 to 1 pound per acre in either dusts or sprays. Two applications 5 to 7 days apart may be required. In the Far West airplane applications have given erratic results on rank cotton. Aramite may be used in spray mixtures with other insecticides. Special care should be used in the preparation of formulations. Aramite has essentially no insecticidal activity.

BHC (benzene hexachloride)

BHC will control the boll weevil, lygus bugs, the rapid plant bug, thrips, stink bugs, the garden webworm, the fall armyworm, the cotton fleahopper, and grasshoppers. It will not control the bollworm, the pink bollworm, the yellow-striped armyworm, spider mites, some species of cutworms, and the salt-marsh caterpillar. It has given erratic results against the cotton leafworm, and it has failed to control the cotton aphid in some areas. It is effective in a dust or spray.

Except for use in early-season control, BHC is usually formulated with DDT in the ratio of 3 parts of the gamma isomer to 5 parts of DDT in both dusts and sprays for use in overall cotton-insect control. This mixture should be applied at the rate of 0.3 to 0.6 pound of the gamma isomer and 0.5 to 1 pound of DDT per acre. In some of the western areas a popular formulation has been 2 parts of the gamma isomer to 5 parts of DDT. Where spider mites are a problem, the dust usually contains at least 40 percent of dusting sulfur. Other dusts contain either 2 or 3 percent of the gamma isomer of BHC and 10 percent of DDT.

Sprays should be formulated to contain the same amounts of each active ingredient as the dusts. It is very important that the emulsifiable concentrate containing BHC be properly formulated to prevent foliage or plant injury.

It is not advisable to use BHC on cotton that will be in rotation with root crops such as Irish potatoes, and in some areas carrots, peanuts, and tobacco.

BHC is toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Calcium Arsenate

Calcium arsenate will control the boll weevil and the cotton leafworm. It has excellent dusting qualities and should be used at the rate of 7 to 10 pounds per acre. Against bollworms 12 to 15 pounds per acre will give only fair control, if applications are properly timed. Generally it is used undiluted against these insects. It often causes an increase in aphid population when used without an aphidicide. Alternate applications of calcium arsenate and an aphidicide have given excellent results in some areas.

Low-lime calcium arsenate is compatible with organic insecticides. In some areas when it is combined with 5 percent of DDT and 1 percent of parathion (see precautions under parathion), boll weevils, bollworms, cotton aphids, and spider mites are controlled. Low-lime calcium arsenate in combination with these materials should be applied at the rate of 10 to 12 pounds per acre.

Calcium arsenate residue in the soil is injurious to some crops, especially legumes and oats in certain light sandy soils. It should not be used in fields where rice may be planted. Drifting of the dust may injure other crops, especially rice, soybeans, pecans, and peaches. Care should be taken to avoid drift that might cause bee losses, or onto pastures, especially when applications are made by airplane. Livestock should be kept out of dusted fields.

Calcium arsenate is toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Chlordane

Chlordane has given good results against the cotton fleahopper, the rapid plant bug, the fall armyworm, the field cricket, grasshoppers, the sand wireworm, darkling ground beetles, and thrips. Results against the boll weevil and lygus bugs have not been consistent. It will not control the bollworm, the pink bollworm, the yellow-striped armyworm, the cotton aphid, stink bugs, or spider mites.

For the insects against which chlordane is effective, from 0.2 to 2 pounds per acre is required.

When used in mid- or late-season treatments for overall cotton-insect control, chlordane should always be formulated with DDT in a 2:1 ratio. From 1 to 1.5 pounds of chlordane and 0.5 to 1 pound of DDT per acre should be applied. It is effective in a dust or spray.

The use of chlordane, alone or with DDT, may result in increased populations of aphids and spider mites.

Chlordane is toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Chlorthion (O-(3-chloro-4-nitrophenyl)-O,O-dimethyl thiophosphate)

Chlorthion is effective against leafhoppers and the boll weevil at a dosage of 0.3 to 1 pound per acre, but it has a short residual toxicity. At 0.25 to 0.5 pound per acre it is effective against the cotton leafworm, the cotton aphid, and two-spotted, strawberry, and desert spider mites. Against thrips it compares favorably in initial kill with recommended insecticides at 0.375 pound per acre, but is lacking in desired residual control. It is effective as a dust or spray. It also shows promise against the cotton leaf perforator and lygus bugs. It is ineffective against the bollworm.

Chlorthion is less toxic to warm-blooded animals than several other phosphorus compounds, but precautions should be exercised in its use until more is known about its toxicity.

See Hazards and Precautions in the Use of Insecticides, p. 5.

DDT

DDT will control the bollworm, the tobacco budworm, the pink bollworm, the fall armyworm, the tarnished plant bug and other lygus bugs, the garden webworm, the western yellow-striped armyworm, the beet armyworm, darkling ground beetles, flea beetles, the white-lined sphinx, the rapid plant bug, the cotton fleahopper, the leaf roller Platynota stultana, and thrips. Unsatisfactory results against thrips have been reported when the temperature exceeded 90° F.

It will also control certain species of cutworms, and to a lesser extent the yellow-striped armyworm. It will not control the boll weevil, the cotton leafworm, the cabbage looper, the salt-marsh caterpillar, spider mites, the cotton aphid, stink bugs in the genera Chlorochroa, Euschistus, and Thyanta, or grasshoppers.

DDT is ordinarily used at the rate of 0.5 to 3 pounds per acre, either alone or mixed with other insecticides and miticides. Sprays and dusts are about equal in effectiveness.

Aphid and mite populations may increase until they cause severe injury where DDT is used, unless an aphidicide or a miticide is included in the formulation.

DDT is toxic to certain plants, such as cucurbits. Its toxicity persists as it accumulates in the soil. Therefore, it should be used only in the minimum amounts recommended for cotton-insect control, especially on light, sandy soils. Contamination of adjacent crops from drift should be avoided.

DDT is toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Demeton (in Systox)

Demeton, the principal active ingredient in Systox, is both a contact and a systemic insecticide with a long period of residual activity. When applied in a foliage spray at 0.125 to 0.4 pound per acre, it is effective against cotton aphids and spider mites for 2 to 8 weeks, and shows promise for control of the leafhopper Empoasca solana. It does not control the boll weevil, the bollworm, the cotton leafworm, the pink bollworm, or grasshoppers.

Demeton is a highly poisonous chemical. It is much more toxic to warm-blooded animals than most chemicals used in cotton-insect control. Therefore, it should be handled with extreme caution, and the directions prescribed by manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Dieldrin

Dieldrin will control the boll weevil, thrips, stink bugs, the cotton fleahopper, lygus bugs, the rapid plant bug, the fall armyworm, grasshoppers, the variegated cutworm, the pale-sided cutworm, the granulate cutworm, the black cutworm, the yellow-striped armyworm, field crickets, and the garden webworm. It is not effective against bollworms at the low dosages usually recommended for boll weevils. Spider mites and aphids may increase where dieldrin is used. Against boll weevils dieldrin should be applied at the rate of 0.15 to 0.5 pound per acre and when bollworms are a problem 0.5 to 1 pound of DDT should be added. Dieldrin will kill newly hatched cotton leafworms at dosages effective against the boll weevil. It is effective in either a dust or spray.

Dieldrin is toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Endrin

Endrin in a spray or dust will control the boll weevil, the cabbage looper, the celery leaf tier, the bollworm, the cotton leaf perforator, lygus bugs, the brown cotton leafworm (Acontia dacia Druce), the cotton leafworm, the salt-marsh caterpillar, the garden webworm, the fall armyworm, grasshoppers, and cutworms when applied at the rate of 0.2 to 0.5 pound per acre; and thrips and the cotton fleahopper at 0.08 to 0.15 pound. It will not control spider mites or the pink bollworm. Aphids usually do not build up after its use.

The acute toxicity of endrin to man and animals is considerably higher than that of dieldrin. It is toxic by skin absorption, by inhalation, and by ingestion. It is recommended for use on cotton only where persons applying it will follow the precautions prescribed by the manufacturers.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Heptachlor

Heptachlor in a spray or dust will control the boll weevil, stink bugs, the garden webworm, grasshoppers, and lygus bugs at dosages ranging from 0.25 to 1 pound per acre. When bollworms are a problem 0.5 to 1 pound of DDT should be added. It is effective against thrips and the cotton fleahopper at dosages ranging from 0.08 to 0.25 pound per acre. It will not control the bollworm, the yellow-striped armyworm, the pink bollworm, the cotton aphid, or spider mites. Spider mite and aphid populations may increase where heptachlor or a heptachlor-DDT mixture is used.

Heptachlor is toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Lindane

Lindane, the essentially pure gamma isomer of BHC, may be substituted for BHC on an equivalent-weight basis for the gamma isomer in formulations used on most cotton insects. Laboratory tests indicate that lindane is slightly less effective than technical BHC against cotton aphids.

Lindane dusted or slurried onto seed at the rate of 1 to 2 ounces per 100 pounds immediately before planting will control wireworms, seedcorn maggots, and false wireworms. The use of fungicides is not covered in this report, but extensive results indicate that a suitable fungicide should be included with lindane seed treatment.

Lindane is toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Malathion

Malathion will control the desert spider mite, the cotton aphid, leafhoppers, whiteflies, the brown cotton leafworm, the cotton leaf perforator, and the cotton leafworm at dosages ranging from 0.25 to 1 pound per acre. It has given poor results against the two-spotted spider mite.

Malathion is less toxic to warm-blooded animals than several other phosphorus compounds, but precautions should be exercised in its use.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Methyl Parathion

Methyl parathion will control the cotton aphid, some species of spider mites, the boll weevil, the cotton leaf perforator, and the cotton leafworm at dosages of 0.25 to 0.5 pound per acre, but it has a short residual toxicity. It is not effective against the bollworm, the pink bollworm, or the two-spotted spider mite. When bollworms are a problem DDT should be added at the rate of 0.5 to 1 pound per acre.

Methyl parathion is a highly poisonous chemical. It is much more toxic to warm-blooded animals than most chemicals used in cotton insect control. Therefore, it should be handled with extreme caution and the directions prescribed by the manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Parathion

Parathion will control the cotton aphid, some species of spider mites, the garden webworm, leafhoppers, the cotton leafworm, the brown cotton leafworm, the cotton leaf perforator, stink bugs, and whiteflies at dosages ranging from 0.1 to 0.5 pound per acre; and the salt-marsh caterpillar at 0.5 to 1 pound per acre. Repeated applications at 1 pound per acre will control the leaf roller Platynota stultana. It may be applied in a dust or spray, alone or with other insecticides. It gives very little control of the boll weevil, the fall armyworm, the variegated cutworm, the bollworm, or the pink bollworm. Bollworm infestations sometimes increase after applications of parathion.

Parathion is a highly poisonous chemical. It is much more toxic to warm-blooded animals than most chemicals used in cotton insect control. Therefore, it should be handled with extreme caution and the directions prescribed by the manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Sulfur

Sulfur has been widely used in dust mixtures on cotton for control of certain species of spider mites and the cotton fleahopper. It has a repressive effect upon aphid populations in some areas. Where the desert spider mite or strawberry spider mite is a problem, at least 40 percent of sulfur should be included in all dusts to prevent damaging infestations of these species and to suppress infestations of others. Sulfur is most effective when finely ground and when the temperature is 90° F. or above. Precautions should be exercised in applying it to cotton adjacent to cucurbits.

Toxaphene

Toxaphene will control the boll weevil, the fall armyworm, the garden webworm, the cabbage looper, the tarnished plant bug, the rapid plant bug, cutworms, lygus bugs, grasshoppers, the cotton leafworm, the salt-marsh caterpillar, and the cotton leaf perforator, when applied at dosages ranging from 1 to 5 pounds per acre. Although toxaphene has been used for control of the bollworm at 2 to 4 pounds and the yellow-striped armyworm at 2 to 3 pounds per acre, other materials have given more satisfactory results. It will control the cotton flea-hopper and thrips when applied at 0.75 to 1 pound per acre. When properly applied, dusts and sprays are about equally effective in most areas.

Control of the bollworm, the salt-marsh caterpillar, and the cotton leaf perforator is improved where sufficient DDT to give 0.25 to 1 pound per acre is incorporated in the toxaphene spray. Toxaphene alone will not give adequate control of the pink bollworm. When used for the control of other insects, it has a repressive effect upon aphid populations, but not sufficient to prevent aphid outbreaks in some areas. The use of toxaphene may result in increased populations of spider mites.

Toxaphene is toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the use of Insecticides, p. 5.

Promising Materials Recommended for Further Experimentation

American Cyanamid 3911 (O,O-diethyl S-ethylmercaptomethyl dithiophosphate)

Am. Cyanamid 3911, a systemic insecticide, is usually impregnated on activated carbon as a 50-50 dust mixture and applied to cottonseed which is planted at a rate to give 1 pound of the insecticide per acre.

In the laboratory it killed thrips, spider mites, the cotton aphid, the boll weevil, and the cotton leaf perforator for 4 to 9 weeks following emergence of the seedling plants.

In 1955 it was widely tested in the field in most States. Excellent control of thrips, the cotton aphid, spider mites, and the serpentine leaf miner was obtained for 4 to 6 weeks after plant emergence. Against the cotton fleahopper it was effective for 3 or 4 weeks. Seed treatment, alone or supplemented with either side dressings or sprays, failed to control the boll weevil in most tests, but gave some control for 3 to 4 weeks in a few. Under some conditions 3911 may adversely affect germination of seeds, and there is some evidence that this chemical exerts certain physiological effects on plants that are not well understood. This insecticide, as a seed treatment, is recommended for large-scale experimentation in 1956.

Am. Cyanamid 3911 is a highly poisonous chemical. It is much more toxic to warm-blooded animals than most chemicals used in cotton insect control. Therefore, it should be handled with extreme caution and the directions prescribed by the manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Bayer L 13/59 (Dipterex) (O,O-dimethyl 2,2,2-trichloro-1-hydroxyethylphosphonate)

Bayer L 13/59 was tested against cotton insects in laboratory and field-cage tests in 1953 and 1954 and in limited field tests in sprays and dusts in 1955. In the laboratory and cage tests dosages of 0.25 to 1 pound per acre were promising against cotton aphids, spider mites, cotton leafworms, and the boll weevil. It was ineffective against bollworms at 2 pounds per acre. Tests also indicate that the compound is effective against moths of the pink bollworm. In field tests it gave generally disappointing results against the boll weevil at 0.5 to 1.8 pounds per acre, but was sufficiently promising to justify further testing at higher dosages. It showed promise for control of aphids, spider mites, and leafworms at 0.5 to 1.5 pounds per acre. It was effective against the salt-marsh caterpillar and the cotton leaf perforator at 1.5 pounds per acre. It did not control bollworms.

Bayer L 13/59 is less toxic to warm-blooded animals than several other phosphorus compounds, but precautions should be exercised in its use until more is known about its toxicity to man and animals.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Bayer 17147 (O,O-dimethyl-S-(4-oxo-benzotriazino-3-methyl) phosphorodithioate)

Bayer 17147 was widely tested across the Cotton Belt in 1955. As a spray or dust it will control the boll weevil, spider mites, the cotton aphid, the garden webworm, the brown cotton leafworm, and the cotton leafworm at dosages of 0.25 to 0.5 pound per acre. At 0.5 to 0.75 pound per acre it controls the pink bollworm, the cotton leaf perforator, and usually the bollworm. Addition of DDT to the lower dosages will give more economical control of the pink bollworm and the bollworm. Against thrips at dosages up to 0.22 pound per acre it was less effective than recommended insecticides and at 0.11 pound per acre was less effective against the cotton fleahopper. It was ineffective against the salt-marsh caterpillar.

Bayer 17147 is a highly poisonous chemical. It is much more toxic to warm-blooded animals than most chemicals used in cotton insect control. Therefore, it should be handled with extreme caution and the directions prescribed by the manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Chipman R-6199 (oxalate salt of O,O-diethyl-O,O-diethylaminoethyl thiophosphate)

R-6199 is a systemic insecticide. In laboratory spray tests it gave good control of spider mites and cotton aphids when applied at the rate of 0.4 ounce per acre, but the period of residual control was short. In field tests at 0.25 pound per acre it gave excellent control of spider mites and the residual control was good, but it did not control the salt-marsh caterpillar at this rate. Because it is not translocated to any great extent from spray applications and has little fumigant activity, plant coverage must be thorough. When applied to the stems of cotton plants in the greenhouse, it was translocated into the leaves and killed first- and second-instar salt-marsh caterpillar larvae. In laboratory tests it was not effective for boll weevil control as a seed treatment, but was promising when applied as a foliage spray. It was not effective as a spray for bollworm control.

Chipman R-6199 is a highly poisonous chemical. It is much more toxic to warm-blooded animals than most chemicals used in cotton insect control. Therefore, it should be handled with extreme caution and the directions prescribed by the manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p. 5.

DDVP (dimethyl 2,2-dichlorovinyl phosphate)

DDVP was widely tested this year in the field both in dusts and sprays, with and without Aroclor, at rates ranging from 0.25 to 0.75 pound per acre. It did not control the boll weevil, bollworm, or pink bollworm, but gave good control of the cotton aphid and spider mites in most tests. In laboratory tests it gave extremely high kill of pink bollworm adults, and had long lasting residual effectiveness when formulated with Aroclor. Aroclor is a mixture of chlorinated terphenyls that reduces the vapor pressure and prolongs residual activity of the insecticide.

DDVP is a highly poisonous chemical. It is much more toxic to warm-blooded animals than most chemicals used in cotton insect control. Therefore, it should be handled with extreme caution and the directions prescribed by the manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Diazinon (O,O-diethyl O-(2-isopropyl-4-methyl-6-pyrimidinyl) thiophosphate)

Diazinon appears promising for the control of spider mites, cotton aphids, and leafhoppers at dosages between 0.125 and 0.5 pound per acre, and is effective against the cotton leaf perforator at 0.5 pound per acre.

Diazinon is a highly poisonous chemical. It is much more toxic to warm-blooded animals than most chemicals used in cotton insect control. Therefore, it should be handled with extreme caution and the directions prescribed by the manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Dilan (1:2 mixture of 1,1-bis(p-chlorophenyl)-2-nitropropane and 1,1-bis(p-chlorophenyl)-2-nitrobutane)

Dilan has been tested against a number of cotton insects in the last few years. For pink bollworm control it gave results comparable to those obtained with DDT on a pound-for-pound basis at rates ranging from 1.5 to 3 pounds per acre. Control of the salt-marsh caterpillar was obtained at 0.6 to 1 pound per acre. It failed to control the cotton aphid, spider mites, and the boll weevil.

Hercules AC 528 (2,3-p-dioxanedithiol S,S-bis(O,O-diethyl-phosphorodithioate))

Hercules AC 528 gave good control of spider mites at 0.4 to 0.6 pound per acre in sprays or dusts in field tests in four States in 1955. It is not a systemic, but has good residual activity. In field tests in California it failed to control leaf rollers at 0.5 pound per acre.

Hercules AC 528 is less toxic to warm-blooded animals than several other phosphorus compounds, but precautions should be exercised in its use until more is known about its toxicity to man and animals.

See Hazards and Precaution in the Use of Insecticides, p. 5.

Rohm & Haas FW-293 (1,1-bis(chlorophenyl) 2,2,2-trichloroethanol)

FW-293 is a miticide with little or no insecticidal activity. When used for control of spider mites it was relatively ineffective at the rate of 0.25 pound per acre, but at the rate of approximately 1.0 pound it was highly promising and the residual period of activity was of long duration.

FW-293 is toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Shell OS-2046 (1-carbomethoxy-1-propen-2-yl dimethyl phosphate)

Shell OS-2046 in limited field tests gave good initial control of the cotton aphid, the cotton leafworm, the bollworm, spider mites, and a leaf roller, Platynota stultana, but it had little residual effectiveness. In laboratory tests against pink bollworm adults it was highly effective both initially and residually. In the laboratory it was also effective against the boll weevil.

Shell OS-2046 is a highly poisonous chemical. It is much more toxic to warm-blooded animals than most chemicals used in cotton-insect control. Therefore, it should be handled with extreme caution and the directions prescribed by the manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Tested Materials of Limited Use

Because other materials proved more effective or more economical or for other reasons, these insecticides are not now in common use on cotton and little research is being done with them. However, because they are known to be effective on certain pests, they are retained in the report in case of possible need due to emergencies, shortages, or for other reasons.

Cryolite

Cryolite as a dust was recommended and extensivelyused in some areas for bollworm control before the organic insecticides became available. It was also widely used in baits for the control of cutworms. Because more effective insecticides are now generally available, cryolite is not recommended for bollworm control, but it is recommended for cutworm control when applied in baits.

See Hazards and Precautions in the Use of Insecticides, p. 5.

EPN (O-ethyl O-p-nitrophenyl benzenethiophosphonate)

EPN was used experimentally for cotton-insect control in 1952 and 1953, but not in 1954 or 1955. It is effective against the boll weevil when applied at 0.5 to 0.75 pound, against the yellow-striped armyworm at 0.3 pound, and against thrips, the cotton fleahopper, the cotton leafworm, and some species of spider mites at 0.25 pound per acre. Aphids and bollworms may build up to damaging numbers after its use, but spider mites do not.

A mixture of EPN and DDT was more effective against the pink bollworm than DDT alone. At 1 pound per acre EPN showed promise for pink bollworm control.

EPN is a highly poisonous chemical. It is much more toxic to warm-blooded animals than most chemicals used in cotton-insect control. Therefore, it should be handled with extreme caution and the directions prescribed by the manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Isodrin

Isodrin was tested for cotton-insect control during 1951, 1952, and 1953. It will control thrips, the cotton fleahopper, and the cotton leafworm, but not the bollworm, the tobacco budworm, the fall armyworm, the yellow-striped armyworm, the pink bollworm, aphids, or spider mites. In South Carolina isodrin applied at 0.2 to 0.4 pound per acre gave satisfactory control of the boll weevil. Erratic control was reported from Texas. When bollworms are a problem, DDT should be added in amounts sufficient to apply 0.5 to 1.0 pound per acre. For thrips and cotton fleahopper control isodrin should be used at 0.2 pound per acre, and for cotton leafworm control at 0.3 pound. It is equally effective in a dust or spray against these pests.

Isodrin is highly toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Lead Arsenate

Lead arsenate was widely used on certain cotton insects for about 50 years, prior to 1945. For control of the cotton leafworm, the bollworm, and the boll weevil it was a close competitor of Paris green until calcium arsenate was used in 1916. It is still used at times against the cotton leafworm. Lead arsenate is poisonous to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Methoxychlor

A dust containing 10 percent of methoxychlor controls the cotton leafworm, but lower concentrations give poor control.

Methoxychlor gives slightly better control of the pink bollworm than DDT, but since a heavy buildup of aphids usually follows its use, it is not being generally used. It will not control the boll weevil, the bollworm, the cotton aphid, the garden webworm, spider mites, or stink bugs.

Nicotine

Two percent of nicotine in calcium arsenate alternated with calcium arsenate alone will usually prevent a cotton aphid buildup, if properly applied. The period between nicotine applications should not exceed 8 to 10 days.

A 3-percent nicotine dust at 10 to 15 pounds per acre in a suitable carrier can be used to knock out heavy aphid infestations. At least 0.3 pound per acre of free-nicotine equivalent should be applied. The source may be either nicotine sulfate or a fixed nicotine in dust form. It should be applied when the air is calm, the temperature is 75° F. or above, and preferably when there is no dew on the plants. Complete coverage is essential.

Nicotine is highly toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Ovex (p-chlorophenyl p-chlorobenzenesulfonate)

Ovex, the active ingredient in Ovotran, will control spider mites when applied at a rate of 2 to 3 pounds per acre. Thorough treatment and contact of the mites is essential for good control. Since its initial action is slow, it will not give immediate knockdown.

Paris Green

Paris green was the first insecticide to be widely used on cotton. Between 1870 and 1910 many million pounds were used for the control of the cotton leafworm alone, and lesser quantities against the bollworm and the boll weevil. Although it is still used in emergencies to control the cotton leafworm, for general use on cotton it was succeeded by lead arsenate and calcium arsenate and later by organic insecticides.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Rotenone

One percent of rotenone in calcium arsenate at each application made against the boll weevil gives satisfactory control of the cotton aphid.

Schradan (octamethylpyrophosphoramide)

Schradan was translocated by cotton plants in laboratory tests when it was applied to soils in which the plants were growing. A single application at the rate of 4 to 8 pounds per acre caused the plants to remain toxic to cotton aphids and spider mites for several months. In laboratory and field tests spray application to foliage at 0.5 to 1 pound per acre gave protection for 2 to 4 weeks. Cotton seedlings grown from seed treated with 1 pound of schradan per 100 pounds of seed were toxic to aphids and mites for 6 weeks. Schradan is ineffective against the boll weevil, the bollworm, the pink bollworm, the cotton leafworm, the cotton fleahopper, thrips, and a number of other cotton insects.

Schradan is a highly poisonous chemical. It is much more toxic to warm-blooded animals than most chemicals used in cotton insect control. Therefore, it should be handled with extreme caution and the directions prescribed by the manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p. 5.

Strobane

Strobane in a spray or dust gave control of boll weevils, lygus bugs, bollworms, and garden webworms about equal to toxaphene in field tests conducted in several states when applied at the rate of 2 to 3 pounds per acre. Aphid buildup sometimes occurred following its use.

Strobane is toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, p. 5.

TEPP (tetraethyl pyrophosphate)

TEPP at 0.5 to 1 pint of the 40-percent concentrate per acre, or its equivalent, will control cotton aphids and some species of spider mites when used on dry plants at proper intervals. Several applications may be required for spider mite control.

This chemical deteriorates rapidly when exposed to moisture and is incompatible with alkaline materials. It should be applied immediately after being mixed with water. Its residual toxicity is very short.

TEPP is a highly poisonous chemical. It is much more toxic to warm-blooded animals than most chemicals used in cotton insect control. Therefore, it should be handled with extreme caution and the directions prescribed by the manufacturers should be strictly followed.

See Hazards and Precautions in the Use of Insecticides, p. 5.

CULTURAL PRACTICES

Certain cultural practices aid in control of cotton insects. Some reduce and under certain conditions may even eliminate the need for insecticides, therefore, they should be encouraged. Several of these practices can be followed by every cotton grower, whereas others are applicable only to certain areas and conditions. Growers following these practices should continue to make careful observations for insects and apply insecticides when needed.

Planting

Reasonably early planting of all cotton within a given area during a short period of time enables the crop to attain maximum growth and fruit before some insects multiply and spread from field to field. Early planting also makes earlier stalk destruction possible.

Varieties

Varieties of cotton that bear prolifically, fruit early, and mature quickly may set a crop before the boll weevil and other insects become numerous. This is especially true when other cultural control practices are followed.

Soil Improvement

Fertilization, rotation of crops, and plowing under of green manure crops are good farm practices and should be encouraged. Although they do not usually contribute directly to insect control, the higher yields give higher returns from the use of insecticides.

Other Host Crops of Cotton Pests

Cotton fields should be located as far as is practicable from other host plants of cotton insects. Thrips breed in onions, potatoes, carrots, legumes, small grains, and some other crops. They later move in great numbers into adjacent or interplanted cotton. Garden webworms, variegated cutworms, stink bugs, and lygus bugs may migrate to cotton from alfalfa. The cotton fleahopper migrates to cotton from horsemint, croton, and other weeds.

Hibernation Areas

The boll weevil hibernates in well-drained, protected areas in and near cotton fields. Spider mites overwinter on low-growing plants in or near fields. Clean cultivation reduces weevil hibernation quarters. Small patches of weeds near fields, along turnrows and fences, or around stumps and scattered weeds in cultivated fields or pastures can be destroyed at small cost. Such practices are more effective where the cotton acreages are in sizeable blocks than in small patches. General burning of ground cover in woods is not recommended.

Seed cotton scattered along roadsides as it is being hauled to the gin may result in the distribution and survival of the pink bollworm. To minimize this hazard trucks, trailers, and other vehicles in which seed cotton is hauled should be tight and covered.

Gin-plant sanitation should be practiced to eliminate hibernating quarters of pink bollworm and boll weevils on such premises. In areas where pink bollworms occur, State and Federal quarantine regulations require that gin trash be burned, sterilized, run through a hammer mill or fan of specified size and speed, composted, or given some other approved treatment.

Early Stalk Destruction

The destruction or killing of cotton plants as early as possible before the first killing frost, by mechanical or chemical methods, forces the boll weevil into starvation before it goes into winter quarters. Early stalk destruction, especially over community- or county-wide areas, has greatly reduced the boll weevil problem in the Lower Rio Grande Valley and other parts of Texas. This practice is also of tremendous importance as an aid in controlling the pink bollworm in most areas of the infested territory. Plowing under the crop residue as deeply as possible after the stalks are cut will further reduce the pink bollworm survival. Modern mechanical stalk cutters and shredders facilitate early stalk destruction and complete coverage of crop residues. The use of these machines should be encouraged as an aid in the control of of the boll weevil and the pink bollworm.

Legumes in Relation to Cotton-Insect Control

Soil-building and soil-conserving leguminous crops are generally fundamental in a cotton-growing program. The fact that a number of insects attack legumes and then transfer to cotton may discourage the use of legumes, but it should not, as insect pests may be controlled on both these crops.

CHEMICAL DEFOLIATION AS AN AID TO INSECT CONTROL

Chemical defoliation of cotton aids in the control of many cotton insects. It usually checks the growth of the plants and accelerates the opening of mature bolls, reducing the damage and the late-season buildup of pink bollworms and boll weevils which would otherwise remain to infest next year's crop. It also prevents or reduces damage to open cotton by heavy infestations of aphids, whiteflies, and the cotton leafworm.

Early defoliation permits quicker harvesting and better use of mechanical pickers. It also permits earlier destruction of the stalks, an important aid in the control of the pink bollworm and the boll weevil. However, if losses in yield and quality are to be avoided, the youngest bolls to make cotton should not be less than 30 to 35 days old at the time of defoliation.

Guides for the use of different defoliants, developed by the Defoliation Conference, have been issued by the National Cotton Council of America, Memphis, Tenn. They contain information concerning the influence of plant activity, stage of maturity, and effect of environment on the efficiency of the process, and give details relative to the various needs and benefits. They explain how loss in yield and quality of products may be caused by improper timing of the applications. These guides are based on broad ecological areas rather than on State boundaries. An individual should consult a local agricultural specialist, if he has any doubt concerning proper methods, time of application, or actual need for the defoliation.

MACHINES OF NO VALUE IN INCREASING YIELDS OF COTTON

Bug-catching Machines

Bug-catching machines are not recommended as a means of controlling cotton insects.

Electronic Devices

No recognized research agency has yet discovered any evidence that would support claims of effectiveness of so-called electronic devices for the control of insects in the field. Such devices are not recommended.

Light Traps

Tests in Texas in 1955 with 144 light traps on 3,000 contiguous acres of cotton and other crops showed them to be of no value in the control of the pink bollworm, the bollworm, or the corn earworm on corn. A heavy infestation of cabbage loopers developed in the light-trap area as well as in the nearby check area, and several applications of insecticides were required to bring this insect under control.

Light traps have provided valuable survey information for the following cotton insects: Bollworm, pink bollworm, cotton leafworm, brown cotton leafworm, cutworms, fall armyworms, cabbage looper, garden webworm, white-lined sphinx, yellow-striped armyworm, yellow woollybear, salt-marsh caterpillar, and beet armyworm.

PRODUCTION MECHANIZATION IN COTTON-INSECT CONTROL

The increased use of tractors for cotton cultivation has made it possible for more insecticides to be applied with the cultivating operations. Tractors also enable the grower to use shredders, strippers, mechanical harvesters, and larger and better plows, all of which help in the control of the pink bollworm and the boll weevil.

The flaming operation for weed control is of questionable value in insect control.

Mechanical pickers appear to have no direct effect on insect control, but in order for them to perform properly cotton plants are usually defoliated by chemicals, and this does have definite value. However, strippers do affect pink bollworm control, for they collect infested bolls from the plants, which are then transported to the gins, where the pink bollworms in the seed or refuse may be more easily destroyed.

Stalk shredders not only destroy certain insects, particularly the pink bollworm, but enable the cotton growers over wide areas to have the stalks destroyed before frost, and thereby stop the development of late generations of this insect and the boll weevil.

Fumigation of mechanical cotton pickers and strippers moving from pink bollworm-infested to noninfested areas is required by quarantine regulations.

COTTON INSECTS AND SPIDER MITES AND THEIR CONTROL

The insects and spider mites injurious to cotton and the recommended chemicals and procedures for their control are discussed in this section. For recommended dosages of the principal insecticides and miticides used for the control of the most important cotton pests see table on page 33.

Recommended Dosages for the Principal Insecticides and Miticides Used for the Control of Certain Cotton Pests

(Pounds per acre of technical material in a dust or emulsion spray)

Pesticide	Boll weevil	Boll-worm	Cotton aphid	Cotton flea-hopper	Cotton leaf-worm	Cut worms	Fall army-worm	Grass hoppers	Lygus and other mirids	Pink boll-worm	Spider mites	Stink bugs	Thrips
Aldrin	0.25-0.75	--	--	0.2	--	--	0.25-0.5	0.10-0.25	0.25-0.75	--	--	--	0.08-0.15
Aramite	--	--	--	--	--	--	--	--	--	--	0.33-1.0	--	--
BHC (gamma)	0.30-0.45	--	0.3-0.6	0.1	--	--	0.4-0.6	0.3-0.5	0.30-0.45	--	--	0.5	0.1-0.2
Calcium arsenate[1/]	7-10	12-15	--	--	7-10	--	--	--	--	--	--	--	--
Chlordane	1.0-1.5	--	--	0.2	--	--	1.5-2.0	0.5-1.5	1.0-1.5	--	--	--	0.5-1.0
Chlorthion	0.30-1.0	--	0.25-0.5	--	0.25-0.5	--	--	--	0.30-1.0	--	0.25-0.5[3/]	--	0.375
DDT	--	0.5-1.5	--	0.5	--	1-2[3/]	0.5-1.0	--	1.0-1.5	2-3	--	--	0.25-1.50
Demeton[2/]	--	--	0.125-0.4	--	--	--	--	--	--	--	0.125-0.4	--	--
Dieldrin	0.15-0.50	--	--	0.1	--	0.3-0.5	0.2-0.3	0.07-0.125	0.15-0.50	--	--	0.5	0.05-0.15
Endrin	0.2-0.5	0.2-0.5	--	0.08-0.15	0.2-0.5	0.2-0.5	0.2-0.3	0.2-0.5	0.2-0.5	--	--	--	0.08-0.15
Heptachlor	0.25-0.75	--	--	0.2	--	--	--	0.25-0.50	0.25-0.75	--	--	1.0	0.08-0.15
Malathion	--	--	0.4-0.75	--	0.25-0.5	--	--	--	--	--	0.25-0.75[3/]	--	--
Methyl parathion	0.25-0.5	--	0.25-0.5	--	0.25-0.5	--	--	--	--	--	0.25-0.5[3/]	--	--
Parathion	--	--	0.1-0.25	--	0.125	--	--	--	--	--	0.1-0.4[3/]	--	--
Sulfur[1/]	--	--	--	--	--	--	--	--	--	--	20-60[3/]	--	--
Toxaphene	2-3	2-4	--	0.75-1.0	1.5-2.0	2-4	2-2.5	1.0-2.5	2-3	--	--	6.0	0.75-1.0

1/ Dust only.
2/ Spray only.
3/ Does not control all species.

Beet Armyworm (Laphygma exigua (Hbn.))

The beet armyworm is primarily a pest of seedling cotton, but it may also attack older plants. Squares and blooms may be destroyed, and feeding on the bracts may cause bolls to shed. DDT at 1 to 1.5 pounds per acre is the most effective control. Toxaphene at 2 to 4 pounds per acre is also effective, but slower in action.

Boll Weevil (Anthonomus grandis Boh.)

The effectiveness of insecticides approved for control of the boll weevil have been observed to vary not only in different localities but also with the season. The choice of insecticides will be determined by their effectiveness in the particular area where the insect is to be controlled. Dosages of technical material that have controlled the boll weevil in one or more areas are as follows:

Insecticide	Pounds per acre
Sprays and dusts:	
Aldrin	0.25-0.75
BHC (gamma isomer)	0.30-0.45
Chlordane	1-1.50
Chlorthion	0.30-1.0
Dieldrin	0.15-0.50
Endrin	0.20-0.50
Heptachlor	0.25-0.75
Methyl parathion	0.25-0.50
Toxaphene	2-3
Dust only:	
Calcium arsenate	7-10

When these insecticides are used for boll weevil control, other insect problems have to be considered. Infestations of the cotton aphid, the bollworm, the tobacco budworm, and/or spider mites may develop when some of these insecticides are used alone. To avoid a rapid build-up of the bollworm and the tobacco budworm, DDT should always be added to aldrin, BHC, chlordane, dieldrin, Chlorthion, methyl parathion, and heptachlor. (For rates see under the respective insecticides or pests.) Toxaphene, if properly timed, will control bollworms without DDT. However, if it is used alone late in the season, careful checks should be made at 3- to 5-day intervals, and if their numbers are found to be increasing, DDT should be included in subsequent applications or should be applied alone.

Aphids may build up rapidly after the use of calcium arsenate or DDT, or DDT formulated with aldrin, chlordane, dieldrin, endrin, heptachlor, or toxaphene. Spider mites may build up rapidly after the use of the last six chemicals and BHC, either alone or with DDT. Careful checks should be made at 5- to 7-day intervals, and if these pests are found to be increasing control measures should be started at once. (See sections on cotton aphids and spider mites.)

Insecticides should be applied for boll weevil control when definite need is indicated. Mid- and late-season applications should be made every 4 to 5 days until the infestation is brought under control. Fields should be inspected weekly thereafter and applications made when necessary. Where early-season control is practiced, these applications are usually spaced a week apart during the period of abundance of overwintered weevils.

Bollworm (Heliothis zea (Boddie))
and Tobacco Budworm (H. virescens (F.))

The bollworm and the tobacco budworm are the common "bollworms" attacking cotton. Several other species of lepidopterous larvae that sometimes also cause boll injury are discussed elsewhere in this report.

It is difficult to control bollworms, and their effective control depends on the thorough and timely use of properly formulated insecticides. Frequent field inspections to determine the presence of eggs and young larvae during the fruiting period are essential. For the most effective control it is essential that insecticide applications be made when larvae are small.

Bollworms are most effectively controlled with DDT or endrin, and in the boll weevil belt are usually satisfactorily controlled with toxaphene.

DDT should be applied at the rate of 0.5 to 1.5 pounds per acre in a dust or spray. In the Far West higher dosages may be needed. It may be used in mixtures with other insecticides where other insects also require control. It is compatible with low-lime calcium arsenate but not with regular calcium arsenate.

Endrin should be applied at 0.2 to 0.5 pound per acre in a spray or dust. The addition of DDT to the minimum dosage will usually be more effective.

Toxaphene at 2 to 4 pounds per acre usually controls the bollworm. It may be applied in a 20-percent dust. When it is applied in a spray the addition of DDT is desirable.

Calcium arsenate is less effective than DDT, endrin, or toxaphene.

In areas where spider mites are a problem, dusts containing organic insecticides should include at least 40 percent of sulfur or an appropriate amount of some other suitable miticide.

Cotton Aphid (Aphis gossypii Glov.)

Heavy infestations of the cotton aphid may occur on cotton after the use of certain insecticides, and on seedling cotton where no insecticides have been applied. Aphid buildup in the boll weevil areas can usually be prevented by the following treatments:

1. A dust or spray containing BHC and DDT applied in every application at 0.3 pound of the gamma isomer and 0.5 pound of DDT per acre.
2. A dust containing 3 percent of gamma BHC, 5 percent of DDT, and 40 percent of sulfur applied at 10 to 12 pounds per acre alternately with calcium arsenate.
3. Parathion 1 percent in low-lime calcium arsenate dust or added at the rate of 0.1 pound per acre to dusts or sprays of the following insecticides when these are formulated with DDT and used at the recommended rate for boll weevil control: Aldrin, dieldrin, heptachlor, and toxaphene.
4. Toxaphene at 2 to 3 pounds per acre in every application (where not formulated with DDT), in a dust or spray.
5. Endrin at 0.2 to 0.5 pound per acre in every application (where not formulated with DDT), in a dust or spray.
6. Methyl parathion at 0.25 to 0.5 pound or Chlorthion at 0.3 to 1.0 pound per acre in a dust or spray, with or without DDT, in every application or alternately with calcium arsenate.

When aphid infestations are heavy and rapid kill is needed, the following treatments are usually effective:

1. BHC or lindane in either a dust or spray to give 0.3 to 0.6 pound of gamma per acre.
2. Parathion in either a dust or spray at 0.1 to 0.25 pound per acre.
3. Nicotine 3 percent in hydrated lime dust at 10 to 15 pounds per acre.
4. Demeton in a spray at 0.125 to 0.4 pound per acre.
5. Malathion in a dust or spray at 0.4 to 0.75 pound per acre.
6. Methyl parathion and Chlorthion in a spray or dust at 0.25 to 0.5 pound per acre.

Cotton Fleahopper (Psallus seriatus (Reut.))

The cotton fleahopper can be controlled with the following dusts applied at the rate of 10 pounds per acre: DDT 5, toxaphene 10, dieldrin 1.5, endrin 1.0, aldrin 2.5, heptachlor 2.5, BHC gamma 1,

and chlordane 2 percent. When spider mites are likely to be a problem, 40 percent or more of sulfur or an appropriate amount of some other miticide should be added.

The following materials may be applied in low-gallonage sprays at the rates indicated per acre: DDT 0.5, toxaphene 0.75 to 1, toxaphene 0.5 plus DDT 0.25, dieldrin 0.1, aldrin 0.2, heptachlor 0.2, chlordane 0.2, BHC gamma 0.1, and endrin 0.08 to 0.15 pound.

Cotton Leaf Perforator (Bucculatrix thurberiella Busck)

The cotton leaf perforator is at times a serious defoliator of cotton in certain areas of southern California and Arizona. It is controlled with DDT in a dust or spray at 1.5 to 3 pounds per acre or with a dust containing 15 percent of toxaphene and 5 percent of DDT at 15 to 25 pounds of the dust per acre. Endrin at 0.4 to 0.5 pound, and parathion or methyl parathion at 0.5 pound per acre are also effective.

Cotton Leafworm (Alabama argillacea (Hbn.))

The cotton leafworm has been controlled successfully for many years with calcium arsenate, Paris green, or lead arsenate. Although effective control has been obtained with a 20-percent toxaphene dust at 10 pounds per acre or with a spray containing 1.5 pounds of toxaphene per acre, recent investigations indicate that higher dosages may now be required. Toxaphene-DDT spray applied at 1 pound of toxaphene and 0.5 pound of DDT, and parathion at 0.125 pound, and endrin at 0.2 to 0.5 pound per acre in dusts or sprays have also been effective. BHC dusts containing 3 percent of gamma, alone or plus 5 percent of DDT, applied at 10 pounds per acre and BHC and DDT sprays at 0.3 pound of gamma and 0.5 pound of DDT per acre have been effective when used in a regular program for the control of other cotton insects. Malathion, methyl parathion, and Chlorthion at 0.25 to 0.5 pound per acre, in dusts or sprays, are also effective.

Cutworms

A number of species of cutworms, including the following, may develop in weeds or crops, especially legumes, and then attack adjacent cotton or cotton planted on land previously in weeds or legumes:

Black cutworm (Agrotis ypsilon (Rott.))
Pale-sided cutworm (Agrotis malefida Guen.)
Variegated cutworm (Peridroma margaritosa (Haw.))
Granulate cutworm (Feltia subterranea (F.))
Army cutworm (Chorizagrotis auxiliaris (Grote))

Recommended control measures include thorough seed-bed preparation, elimination of weed host plants, and the use of insecticides. In western areas irrigation forces the subterranean forms to the surface, where they may be treated with insecticides or destroyed by natural factors. If an infested area is plowed under 3 to 6 weeks before the cotton crop is seeded, it may not be necessary to use an insecticide.

The following sprays are effective against cutworms: Toxaphene at 2 to 4 pounds, toxaphene-DDT (2:1) at 2 to 4 pounds of total toxicant, DDT at 1 to 2 pounds for most species, dieldrin at 0.3 to 0.5 pound, and endrin at 0.2 to 0.5 pound per acre. A 20-percent toxaphene or 10-percent DDT dust applied at 10 to 25 pounds per acre will give satisfactory control. Poison baits containing Paris green cryolite, sodium fluosilicate, toxaphene, DDT, dieldrin, or endrin have been satisfactory. Baits are frequently more effective than sprays or dusts against some species of cutworms.

Fall Armyworm (Laphygma frugiperda (J. E. Smith))

The fall armyworm occasionally occurs in sufficient numbers to damage cotton. The following dusts applied at 10 to 15 pounds per acre have given good control: Toxaphene 20 percent, BHC sufficient to give 3 percent of the gamma isomer plus 5 percent of DDT, DDT 10 percent, or endrin 2 percent. A 10-percent chlordane dust at 15 to 20 pounds per acre is also effective. Toxaphene at 2 to 2.5 pounds and DDT at 0.5 to 1 pound per acre in sprays have given good control. Other insecticides that have been effective when applied in sprays are dieldrin or endrin 0.2 to 0.3 pound, BHC containing 0.4 to 0.6 pound of gamma, or aldrin 0.25 to 0.5 pound per acre. The results obtained from these materials have varied in different States; therefore, local recommendations should be followed. (Also see Bollworms, p. 35.)

False Wireworms (Blapstinus and Ulus spp.)

Darkling ground beetles, the adults of false wireworms, occasionally affect the stand of young cotton in the western areas. The larvae may be controlled by slurrying 2 ounces of aldrin, dieldrin, endrin, heptachlor, or lindane with a suitable fungicide onto each 100 pounds of planting seed. Adults on young plants may be controlled with 5-percent chlordane dust at 20 pounds, or with toxaphene, DDT, or toxaphene-DDT mixture (2:1) applied in sprays at 1 to 2 pounds per acre. Sprays containing dieldrin at 0.25 pound or aldrin at 0.5 pound per acre have given excellent control.

Field Cricket (Acheta assimilis F.)

The field cricket occasionally feeds on cotton bolls and seedling plants in the Imperial Valley of California and in Arizona. During periods of drought late in the season they may feed on the seed of open bolls, especially in the Delta sections of Arkansas, Louisiana, and Mississippi. This feeding is usually done at night by crickets that hide during the day in deep cracks in the soil. Crickets may be controlled by foliage applications of a 10-percent DDT or 5-percent chlordane dust at 20-25 pounds or 2.5-percent dieldrin or aldrin dust at 20-30 pounds per acre. A dust containing sufficient BHC to give 2 percent of gamma plus 5 percent of DDT plus 40 percent of sulfur applied at 15-20 pounds per acre is also effective.

Garden Webworm (Loxostege similalis (Guen.))

The garden webworm may be controlled on cotton with the following insecticides applied as dusts or sprays at the per-acre dosage indicated: BHC-DDT to give 0.45 pound of gamma and 0.75 pound of DDT, toxaphene at 3 pounds, parathion at 0.15 pound, DDT at 1 pound, toxaphene-DDT (3:1) at 3 pounds, heptachlor at 0.4 pound, dieldrin at 0.3 pound, and endrin at 0.3 pound. DDT has given better control in sprays than in dusts, but is generally less effective than the other materials. Control measures should be applied as soon as possible after the worms appear. After webbing becomes extensive, it is difficult to get the insecticide in contact with the insect.

Grasshoppers

Several species of grasshoppers, including the following, sometimes attack cotton:

Differential grasshopper (Melanoplus differentialis (Thos.))
Migratory grasshopper (M. mexicanus (Sauss.))
Red-legged grasshopper (M. femur-rubrum (Deg.))
Two-striped grasshopper (M. bivittatus (Say)
American grasshopper (Schistocerca americana (Drury))
Lubber grasshopper (Brachystola magna (Gir.))

The American grasshopper overwinters as an adult, and in the spring deposits eggs in the fields, but most other species overwinter as eggs in untilled soil, fence rows, sod waterways, around stumps, and similar locations. The species overwintering in the egg stage can best be controlled with early treatment of hatching beds before the grasshoppers migrate into the fields. Sprays or dusts containing aldrin,

chlordane, heptachlor, dieldrin, endrin, toxaphene, or BHC have largely replaced poison baits, particularly where grasshoppers must be controlled on lush or dense vegetation.

BHC sprays and dusts usually kill the grasshoppers in a few hours, but results have been erratic and residual effectiveness is limited to 1 to 2 days. Aldrin, chlordane, dieldrin, endrin, and toxaphene are very effective but slower in their action; however, they remain effective up to several weeks.

Dosages of technical material suggested to control grasshoppers come within the following ranges:

Insecticide	Pounds per acre
Aldrin	0.1-0.25
BHC, gamma	0.3-0.5
Chlordane	0.5-1.5
Dieldrin	0.07-0.125
Endrin	0.2-0.5
Heptachlor	0.25-0.5
Toxaphene	1.0-2.5

The lowest dosages are effective against newly hatched to half-grown grasshoppers. The dosage should be increased as the grasshoppers mature or when the material is applied on partly defoliated plants or on plants unpalatable to the insects.

Baits made according to State and Federal recommendations still have a place in grasshopper control, particularly in sparse vegetation.

Lygus Bugs and Other Mirids

Several species of lygus bugs and other mirids, including the following, are often serious pests of cotton:

Tarnished plant bug (Lygus lineolaris (P. de B.))
Other lygus bugs (L. hesperus Knight and elisus Van D.)
Rapid plant bug (Adelphocoris rapidus (Say))
Superb plant bug (A. superbus (Uhl.))
Ragweed plant bug (Chlamydatus associatus (Uhl.))
Other mirids (Creontiades debilis (Van D.), C. femoralis (Van D.), and Neurocolpus nubilus (Say))

These insects cause damage to squares and small bolls of cotton and constitute a major problem, particularly in the vicinity of alfalfa fields in the irrigated areas of the West. DDT at 1 to 1.5 pounds and toxaphene at 2 to 3 pounds per acre are widely used for the control of these insects. The other organic insecticides recommended for boll weevil and bollworm control are also effective against mirids.

Pink Bollworm (Pectinophora gossypiella (Saund.))

The pink bollworm caused considerable damage in many of the cotton fields in central Texas in 1955. Moderate to severe crop losses also occurred in the Coastal Bend and in a few fields in the Lower Rio Grande Valley, the Pecos area, the El Paso Valley, and the Mesilla Valley of New Mexico. Inspection at then end of the season showed distribution as indicated on the map on page 42.

Quarantine Requirements.--Quarantine requirements have changed as new methods have been developed and additional information has become available. Since the area under the pink bollworm quarantine is so large and the volume and value of the regulated commodities are so great, it is essential that regulations not only provide safeguards against the spread of the pest but also be practical and not unreasonably severe. Recent changes, such as the use of fans for the treatment of oil-mill products and gin trash, have resulted in substantial savings to the cotton trade without increasing the pest risk. Additional changes may be made as new research information is available.

Regulations in general require that cotton, cotton products, and all articles associated with the production, processing, or handling of cotton be so treated as to render them free of pink bollworms before they are moved to nonquarantined areas. So far as is known, no new infestation has ever resulted from the movement of certified products from the quarantined area.

Cultural Control.--The pink bollworm, unlike any other cotton insect, hibernates only in the cotton fields in which it is produced unless taken from the fields in the harvesting of the crop. Cultural control greatly reduces the overwintering population and is the most effective means of combating this pest. Mandatory cultural control zones are in effect in all the regulated areas of Arkansas and Louisiana, in all of south Texas, and in the southern portion of central and east Texas. There are also mandatory cultural control zones in Mexico adjacent to Texas.

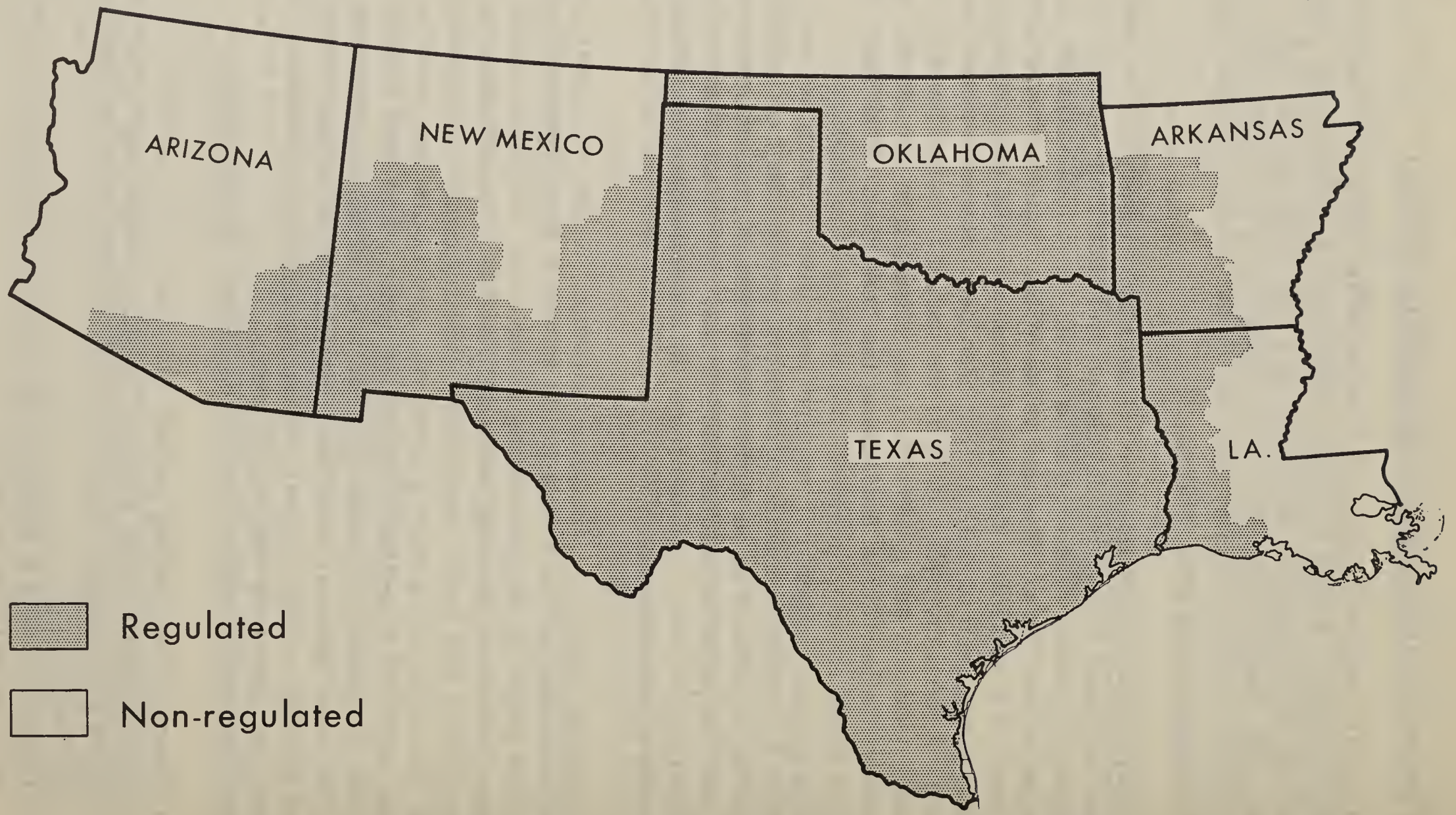
The same cultural practices followed in the control of the pink bollworm greatly reduce the boll weevil carryover, particularly when the plants are destroyed while still green.

Recommended control practices include the following:

1. Shorten the planting period and plant at the optimum time for your locality. Use seeds of an early-maturing variety that have been culled, treated with a fungicide, and tested for germination.
2. Leave as thick a stand as has been recommended for your section and type of soil.

PINK BOLLWORM REGULATED AREAS

January 1, 1956



U. S. DEPARTMENT OF AGRICULTURE

AGRICULTURAL RESEARCH SERVICE

3. Practice early-season control as recommended for your State and locality by controlling the early cotton insects, such as thrips, aphids, the cotton fleahopper, the boll weevil, and cutworms, which may retard the growth and fruiting of the young plants. By protection of early fruit an early harvest can be assured.
4. Destroy stalks immediately after harvest, preferably by shredding. The shredder has killed 70 to 75 percent of pink bollworm larvae in green bolls in south Texas.
5. Withhold late irrigation, and use defoliants or desiccants to hasten the opening of the bolls.

After the stalks have been destroyed, the residue should be plowed under as deeply as possible. Pink bollworm survival is highest in bolls on the soil surface and is six times as high in bolls buried only 2 inches deep as in bolls buried 6 inches deep. All sprout and seedling cotton developing after plowing should be destroyed before fruiting to create a host-free period between crops.

In cold arid areas where temperatures of 15° F. or lower prevail, stalks should be left standing during the winter, since the highest mortality is such areas occurs in bolls on the standing stalks. If the crop debris is plowed under in the late fall or early winter, the fields should be winter-irrigated to hasten decomposition of the bolls.

These recommended measures are most effective when carried out on a community or county-wide basis, and these practices will pay large dividends in savings on insecticides.

Control with Insecticides.--Where heavy infestations develop, crop losses from the pink bollworm can be reduced by proper use of insecticides. DDT is effective against the pink bollworm when applied weekly in either a dust or spray at the rate of 2 to 3 pounds per acre. When the boll weevil also requires control, DDT can be mixed with other organic insecticides or with low-lime calcium arsenate. When the interval of application is reduced to 4 or 5 days for control of other insects, the quantity of DDT may be reduced accordingly, or to 1 to 1.5 pounds per acre in combination with other insecticides. Thorough coverage of the plants is essential.

The following methods of inspection should be used in determining field infestation of the pink bollworm:

Bloom Inspection.--After the cotton has been blooming for at least 5 days, inspect a representative number of blooms for those rosetted or infested (blooms with the petals webbed together at the tips). At each of five representative locations in the field, step off 300 feet of

row and count the rosetted blooms. The total number of worms in these rosetted blooms multiplied by 10 will give the approximate number of worms per acre.

Boll Inspection.--Walk diagonally across the field and collect at random 100 firm speckled bolls. Remove the bracts from each boll by cutting off a small layer from the base; cut each section of the boll lengthwise (midway between the sutures) so that each lock can be removed intact; examine the inside of the boll wall for the characteristic tunnels or mines made by the small worms; then examine the locks for the presence of worms.

Seed-Corn Maggot (Hylemya cilicrura (Rond.))

The seed-corn maggot may seriously affect the stand of cotton, particularly when planting closely follows the turning under of a green manure crop or other heavy growth. This insect may be controlled with 1 to 2 ounces of aldrin, dieldrin, endrin, heptachlor, or lindane in a wettable powder mixed with a suitable fungicide and applied onto each 100 pounds of planting seed. Seed should be treated immediately before planting.

Spider Mites

The following spider mites are known to attack cotton:

Strawberry (Atlantic) spider mite (Tetranychus atlanticus McG.)
Two-spotted spider mite (T. telarius (L.) = bimaculatus Harvey)
Four-spotted spider mite (T. canadensis McG.)
Desert spider mite (T. desertorum Banks)
Pacific spider mite (T. pacificus McG.)
Schoene spider mite (T. schoenei McG.)
Tumid spider mite (T. tumidus Banks)
Brown wheat mite (Petrobia latens (Muell.))
Also T. cinnabarinus (Boisduval), T. lobosus Boudreaux,
T. gloveri Banks, and T. ludeni Zacher

Tetranychus cinnabarinus replaces T. bimaculatus multisetis (McG.) as the carmine phase of the two-spotted spider mite. This change, authored by H. B. Boudreaux, will be published soon.

These species differ in their effect on the cotton plant and in their reaction to miticides. Accurate identification of the species is essential. The use of organic insecticides for cotton-insect control has been a factor in increasing the importance of spider mites as pests of cotton.

The two-spotted spider mite and T. cinnabarinus are the most difficult species to control on cotton. Both can be controlled with demeton at 0.125 to 0.4, Aramite a 1, and Chlorthion at 0.25 to 0.5 pound per acre. Parathion at 0.2 to 0.4 pound per acre is also effective in some localities.

The Pacific spider mite is restricted to the Pacific Coast, where it has been a major pest of cotton. Sulfur at 60, demeton at 0.25 to 0.40, and Aramite at 1 pound per acre will control this species. The other organic phosphorus compounds are not satisfactory.

The strawberry spider mite first attacks the lower leaves of the plant and causes severe defoliation. Demeton at 0.25 to 0.40, Aramite at 1, Chlorthion at 0.25 to 0.5, and sulfur at 20 to 25 pounds per acre will control this mite.

The desert and tumid spider mites are controlled with sulfur at 20 to 25, parathion at 0.1 to 0.25, methyl parathion at 0.25 to 0.5, malathion at 0.25 to 0.75, Aramite at 0.3 to 0.75, and Chlorthion at 0.25 pound per acre.

The brown wheat mite may attack seedling cotton in the Far West. Parathion at 0.3 pound and sulfur at 25 to 30 pounds per acre during warm weather will control this species.

In some areas mites may be controlled by including a suitable miticide at a comparatively low rate in all insecticide applications. For control of some species and suppression of others at least 40 percent of sulfur may be incorporated in dusts. Elemental sulfur cannot be incorporated in sprays applied at low gallonage, but other miticides may be substituted. Sulfur dust is most effective when finely ground and when applied at temperatures above 90° F. Thorough coverage is essential.

Stink Bugs

The following stink bugs are sometimes serious pests of cotton:

Conchuela (Chlorochroa ligata (Say))
Say stink bug (C. sayi Stal.)
Southern green stink bug (Nezara viridula (L.))
Green stink bug (Acrosternum hilare (Say))
Brown cotton bug (Euschistus impictiventris Stal.)
Brown stink bug (E. servus (Say))
(also E. variolarius (P. de B.), tristigmus (Say), and conspersus Uhl.)
Red-shouldered plant bug (Thyanta custator (Fab.))
(also T. rugulosa (Say), brevis Van D., and punctiventris Van D.)

The importance of these pests and the species involved vary from year to year and from area to area. The damage is confined principally

to the bolls and results in reduced yields and lower quality of both lint and seed. Dieldrin and gamma BHC at 0.5 pound and heptachlor at 1 pound per acre give good control of these stink bugs. Toxaphene at 6 pounds per acre gives fair to good control and is sometimes preferred where there is hazard to bees. A dust containing sufficient BHC to give 2 percent of gamma, 5 percent of DDT, and 50 percent of sulfur applied at 15 to 30 pounds per acre also gives control of stink bugs, lygus bugs, bollworms, and cotton aphids, and is widely used for the control of these pests in the western areas.

Thrips

Thrips often cause injury to cotton seedlings, especially in areas where vegetables, legumes, and small grains are grown extensively. The following species have been reported as causing this injury:

Tobacco thrips (Frankliniella fusca (Hinds))
Flower thrips (F. tritici (Fitch))
(also F. runneri (Morg.), exigua Hood, and occidentalis (Perg.))
Onion thrips (Thrips tabaci Lind.)
(also Sericothrips variabilis (Beach))

In some areas cotton plants usually recover from thrips injury to seedlings, so that control is not recommended unless the stand is threatened. In other areas thrips damage is more severe and control measures are generally recommended. The destruction of leaf tissue and subsequent slowing of plant growth may make the seedlings more susceptible to diseases. Injury by thrips alone or the combined injury of thrips and disease may reduce or even destroy stands of young plants. A heavy infestation may retard plant growth and delay fruiting and crop maturity. Although thrips are predominantly pests of seedling cotton, damaging infestations sometimes occur on older cotton in certain areas.

The following insecticides applied in sprays or dusts at the per-acre dosages indicated are recommended when the situation warrants their use: Toxaphene 0.75 to 1; BHC gamma 0.1 to 0.2; BHC gamma 0.15 plus DDT 0.25; aldrin, endrin, and heptachlor 0.08 to 0.15; dieldrin 0.05 to 0.15; chlordane 0.5 to 1; DDT 0.25 to 1.5 pounds. DDT has not given satisfactory control at temperatures above 90° F. Sprays are more effective than dusts on seedling cotton. When application is made by airplane, the dosage should be increased by at least 50 percent.

Parathion, methyl parathion, and Chlorthion are effective against thrips but are not generally recommended because their residual toxicity is shorter than that of insecticides commonly used for thrips control.

The bean thrips (Hercothrips fasciatus (Perg.)) is a common mid-season pest of cotton in parts of California. DDT at 1 pound or toxaphene at 2 to 3 pounds per acre gives satisfactory control when applied in either a spray or dust.

White-fringed Beetles (Graphognathus spp.)

White-fringed beetles are pests of cotton and many other farm crops in limited areas of Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee. The larvae feed on the roots of young plants. These insects can be controlled by good cultural practices and with insecticides. Recommended cultural practices include the following:

1. In heavily infested areas plant oats or other small grains.
2. Restrict planting of summer legumes, such as peanuts, soybeans, velvetbeans, or other favorable host plants of the adult beetles, to not more than one-fourth of the total crop land. Do not plant these crops on the same land more often than once in 3 or 4 years.
3. Do not intercrop corn with peanuts, soybeans, crotolaria, or velvetbeans. Prevent the growth of broadleaved weeds such as cocklebur and sicklepod.
4. Improve poor soils by turning under winter cover crops.

The following insecticides when applied at the given dosages are effective against white-fringed beetle larvae. Either broadcast the insecticide on the soil when preparing it for planting, and immediately work it thoroughly into the upper 3 inches, or apply it alone or mixed with fertilizer, below the depth of seed in the drill row at time of planting. The insecticide may be used in the form of a spray, dust, or granules.

	Pounds per acre	
	Broadcast	In drill row
Aldrin	3	0.75
Chlordane	5	1
DDT	10	2
Dieldrin	1.5	0.5
Heptachlor	3	0.75

Broadcast applications remain effective as follows: Aldrin, chlordane, or heptachlor, for 3 years; DDT, for 4 years; and dieldrin, for 4 or more years. Drill-row applications must be renewed each year.

Either toxaphene or a BHC-DDT mixture applied on cotton foliage gives a residue in the soil which aids in the control of white-fringed beetles. Any one of the insecticides named above, as well as toxaphene or a BHC-DDT mixture, as recommended for the control of other cotton insects and applied to the foliage gives a residue in the soil which aids in the control of white-fringed beetles.

Whiteflies (Trialeurodes abutilonea (Hald.) and vaporariorum Westw.)

Whiteflies are usually kept in check by parasites and diseases, but occasionally may be serious late in the season. Parathion at 0.125 to 0.5 or malathion at 0.25 to 0.75 pound per acre is effective, but repeated applications may be necessary.

Wireworms

Several species of wireworms are associated with cotton. Damage is caused by the sand wireworm (Horistonotus uhlerii Horn.) in South Carolina, Louisiana, and Arkansas and by the Pacific Coast wireworm (Limonius canus Lec.) in California. Adults of the tobacco wireworm or spotted click beetle (Conoderus vespertinus (F.)) are frequently found on the cotton plant, but the amount of damage the larvae cause to cotton is not known. Wireworms together with false wireworms and the seed-corn maggot sometimes prevent the establishment of a stand. To control these insects treat the seed with 1 to 2 ounces of aldrin, dieldrin, endrin, heptachlor, or lindane plus a suitable fungicide per 100 pounds in a slurry.

Approved crop-rotation practices, increased soil fertility, and added humus help to reduce damage to cotton by the sand wireworm. Chlordane and BHC are also effective against wireworms.

Yellow-striped Armyworm (Prodenia ornithogalli Guen.), and Western Yellow-striped Armyworm (P. praefica Grote)

These insects sometimes cause considerable damage to cotton. The yellow-striped armyworm is difficult to kill with insecticides. EPN at 0.3 pound per acre applied in an emulsion spray is superior to any of the chlorinated hydrocarbons. However, toxaphene at 2.5 pounds, DDT at 1 pound, and dieldrin at 0.3 pound per acre in an emulsion spray gives fair control when used in the early stages of worm development. Dieldrin in a 3-percent dust and toxaphene in a 20-percent dust applied at 15 pounds of dust per acre also give good kills of both large- and small-size yellow-striped armyworm larvae.

The western yellow-striped armyworm, which attacks cotton in California, is easily controlled with DDT at 1 to 1.5 pounds or toxaphene at 2 to 3 pounds per acre applied in a dust or spray. Migrations from surrounding crops may be stopped with barriers of 10-percent DDT or 20-percent toxaphene at 2 to 4 pounds per 100 feet.

Miscellaneous Insects

Several Anomis leafworms are known to occur in the cotton-growing regions of Africa, Asia, North, Central, and South America, and the East and West Indies. Three species--erosa Hbn., flava fimbriago Steph.,

and texana Riley--occasionally occur and damage cotton in the United States. They are often mistaken for the cotton leafworm, and at times they occur on the same plants with it. Although specific control data are lacking, the insecticides recommended for control of the cotton leafworm might also be effective against Anomis leafworms.

The brown cotton leafworm (Acontia dacia Druce) was collected on cotton in Austin, Robertson, and Wharton Counties, Tex., in 1953, but no damaging infestations were found. Injurious infestations occurred on several thousand acres in the Brazos River bottom of Brazos, Burleson, and Robertson Counties and on a few hundred acres in each of Wharton and Matagorda Counties in July 1954. Light infestations were found in Natchitoches and Red River Parishes, La., in October 1954. In Brazos, Burleson, and Robertson Counties control measures were required in many fields early in the 1955 season and many cotton fields were defoliated by the pest after the cotton matured. Laboratory and field tests conducted at College Station, Tex., and commercial use showed that this pest may be controlled with parathion at 0.125 pound, malathion at 0.25 pound, and endrin at 0.33 pound per acre. Toxaphene, DDT, BHC, cryolite, and calcium arsenate were ineffective at dosages recommended for the control of other cotton insects.

The cabbage looper (Trichoplusia ni (Hbn.)) and related species occasionally cause damage to cotton in localized areas. A dust containing 2 percent of endrin or 5 percent of DDT plus 15 percent of toxaphene at 20 to 30 pounds per acre is effective. A spray containing endrin at 0.4 to 0.5 pound or DDT at 1.5 pounds plus toxaphene at 3 pounds per acre is also effective. Toxaphene at 2 to 3 pounds per acre in a dust or spray has given erratic results.

Forms of the genus Colaspis are widespread and often certain ones are found on cotton, frequently near the base of squares and bolls where they usually feed on the bracts surrounding them, causing a characteristic type of injury.

The corn silk beetle (Luperodes brunneus (Crotch)) has been reported as a pest of cotton in localized areas in South Carolina, Georgia, Alabama, Mississippi, and Louisiana, but little is known about it. Damage by this insect was reported from Mississippi during 1955.

Root aphids known to attack cotton are the corn root aphid (Anuraphis maidi-radicis (Forbes)), Trifidaphis phaseoli (Pass.), and Rhopalosiphum subterraneum Mason. So far as is known, injury is confined to the Eastern Seaboard. Several species of ants are known to be associated with root aphids, the principal one being the cornfield ant (Lasius alienus americanus Emery). Chemical control of root aphids has been directed at the control of this ant. Some of the new materials are known to be effective as soil insecticides, and it is suggested that they be tested against root aphids attacking cotton. Root aphids injure cotton chiefly in the seedling stage. Since cotton in this stage often shows injury

without any evidence of insects being present, the underground portions should be examined carefully. Ant mounds at the base of these plants indicate the presence of root aphids.

The cotton square borer (Strymon melinus (Hbn.)) occurs throughout the Cotton Belt, but rarely causes economic damage. The injury this insect causes to squares is often attributed to the bollworm.

The cotton stainer (Dysdercus suturellus (H.-S.)) is found within the United States in Florida only. However, probably owing to mistaken identity, the literature also records it from Alabama, Georgia, and South Carolina. No work on control has been formally reported in recent years, but observations indicate that dusts containing 10 percent of toxaphene or BHC 1 percent gamma will control insects of this genus. DDT may also be effective.

The cotton stem moth (Platyedra vilella (Zell.)), a close relative of the pink bollworm, was first discovered in the United States in 1951, when larvae feeding in hollyhock seed at Mineola, Long Island, N. Y., were collected by J. H. Maheny, and determined by H. W. Capps of the former Bureau of Entomology and Plant Quarantine. It is recorded as a pest of cotton in Iran, Iraq, Morocco, Transcaucasia, Turkestan, and U.S.S.R., and as feeding on hollyhock and other malvaceous plants in England, France, and central and southern Europe. Collections made in 1953 extended its known distribution in this country to a large part of Long Island and to limited areas in Connecticut and Massachusetts. Extensive scouting during 1954 disclosed that it had reached 11 counties in 4 States, as follows: Connecticut: Hartford and New Haven; Massachusetts: Essex and Plymouth; New Jersey: Monmouth, Ocean, and Union; New York: All counties of Long Island (Nassau, Queens, and Suffolk) and Westchester. There was no reported spread in 1955. Although this species has not been found on cotton in the United States, it is desirable to keep on the lookout for it on cotton, hollyhock, and other malvaceous plants.

The cowpea aphid (Aphis medicaginis Koch), the green peach aphid (Myzus persicae (Sulz.)), and the potato aphid (Macrosiphum solanifolii (Ashm.)) are common on seedling cotton. Cotton is not believed to be a true host of these species.

The cowpea curculio (Chalcodermus aeneus Boh.) sometimes causes damage to seedling cotton.

The European corn borer (Pyrausta nubilalis (Hbn.)) was first reported on cotton in the United States during 1955. The first report came from Franklin County, Tennessee, where a few plants near the edge of a field were severely damaged. This was on July 3 in a 3-acre field adjacent to one that was in corn the previous year. The cotton was only 8 to 10 inches high at that time, and the larvae had entered the stems 2 to 6 inches from the ground and burrowed up through their centers. In August light infestations were reported in cotton in Dunklin, New Madrid, Pemiscot, Butler, Stoddard, and Mississippi Counties in

Missouri, and in Madison County, Tennessee. The borers were found boring into the upper third of the stems, and second- and third-instar larvae were found attacking small bolls. These records are of special interest in view of the fact that the European corn borer is apparently spreading in the Cotton Belt. In other parts of the world, particularly in Russia, Turkestan, and Hungary, it has been reported as a serious pest of cotton. One reference states "In Turkestan it is principally cotton which is attacked by the larvae and in which they bore long tunnels in the upper part of the stems." Entomologists and other interested persons throughout the Cotton Belt should be on the alert to detect the presence of this insect on cotton and, wherever possible, record the type and degree of injury, their seasonal and geographical distribution on cotton, and control measures that might be of value.

The pale-striped flea beetle (Systena blanda Melsh.), the elongate flea beetle (S. elongata (F.)), and S. frontalis (F.) sometimes cause serious damage to seedling cotton in some areas. They can be controlled with chlordane at 0.5 pound, aldrin at 0.25 to 0.5 pound, dieldrin at 0.25 to 0.33 pound, DDT at 1 pound, or toxaphene at 2 to 3 pounds per acre in dusts or sprays. The sweetpotato flea beetle (Chaetocnema confinis Crotch) was found injuring seedling cotton in the piedmont section of South Carolina in May 1954. Other species of flea beetles have been reported from cotton, but records regarding the injury they cause are lacking. When flea beetle injury to cotton is observed, specimens of the insects should be submitted to specialists for identification with a statement regarding the damage they cause, the locality, and the date of collection.

The greenhouse leaf tier (Udea rubigalis (Guen.)), also known as the celery leaf tier, became extremely abundant on cotton in the San Joaquin Valley in 1954. Despite the heavy populations, damage was generally slight and restricted to foliage on the lower third of the plants in lush stands. In the few places where it was necessary to control this pest, a dust containing 5 percent of DDT plus 10 to 15 percent of toxaphene at 25 to 35 pounds per acre or endrin at 0.4 pound per acre in a dust or spray was effective.

Several leafhoppers of the genus Empoasca are often found abundant on cotton in many sections of the cotton belt. Only in California, however, has serious injury been reported and this was caused by two species, solana De L. and fabae (Harris). These species are known to be phloem feeders on some crops and cause damage typical of this type of feeding on cotton. In the San Joaquin Valley, where fabae occurs, satisfactory control has been obtained with 1 to 1.5 pounds of DDT per acre. In the desert areas, where solana occurs, parathion at 0.25 to 0.5 and malathion at 0.75 pound per acre have given satisfactory results.

Several of the leaf rollers (Tortricidae) occasionally damage cotton. Platynota stultana (Wlsm.) and rostrana (Wlk.) are the species most commonly recorded, but flavedana Clem., idaeusalis (Wlk.), and

nigrocervina (Wlsm.) have also been reported. These species are widely distributed and have many host plants. P. stultana has at times been a serious pest of cotton in the Imperial Valley of California and parts of Arizona and New Mexico. DDT at 2 to 3 pounds and parathion at 1 pound per acre were the most promising of the materials tested.

The pink scavenger caterpillar (Pyroderces rileyi (Wlsm.)) is one of several insects that resemble the pink bollworm. The larva is primarily a scavenger in cotton bolls and corn husks that have been injured by other causes. It is sometimes mistaken by laymen for the pink bollworm.

The salt-marsh caterpillar (Estigmene acrea (Drury)) can be controlled with a dust or spray containing DDT-toxaphene (1:3) applied at 4 to 6 pounds of total toxicant, parathion at 0.5 to 1 pound, or Dilan at 0.6 to 1 pound per acre; a spray of endrin at 0.4 to 0.5 pound per acre is also effective.

The serpentine leaf miner (Liriomyza subpusilla (Meig.)) has been present in large numbers in some cotton fields in Texas during the last 3 years. Drouth conditions favor infestations of this pest. Heavy infestations may result in considerable leaf shed. Field tests at Waco showed that the best reductions were obtained with parathion at 0.25 pound per acre; in some tests good reductions were obtained with Chlorthion at 0.25 to 0.5 pound. Dieldrin, toxaphene, endrin, heptachlor, and DDT at dosages generally recommended for the control of other cotton insects were ineffective.

The stalk borer (Papaipema nebris (Guen.)) is widely distributed east of the Rocky Mountains. It attacks many kinds of plants, including cotton, and is so destructive that one borer in a field may attract attention. The borers are most likely to be noted near the edges of cotton fields. Clean cultivation and keeping down weed growth help to hold them in check. The use of stalk shredders early in the fall should reduce their numbers. Information is needed concerning the effectiveness of chemicals for the control of this insect.

The white-lined sphinx (Celerio lineata (F.)) occasionally occurs in large numbers in uncultivated areas and migrates to cotton. It may be controlled on cotton with DDT at 1 to 1.5 pounds or toxaphene at 2 to 3 pounds per acre in a dust or spray. Migrations may be stopped with barrier strips of 10-percent DDT or 20-percent toxaphene or physical barriers.

Occasionally the yellow woollybear (Diacrisia virginica (F.)) and the hairy larvae of several other tiger moths (Arctiidae), including Callarctia phyllira (Drury), C. arge (Drury), and C. oithona Strk., cause serious damage to cotton. Information is needed in regard to their seasonal host plants, distribution, natural enemies, causes of serious outbreaks in cotton fields, life history, and control. Determinations by specialists should always be obtained.

Honeydew from aphids causes gummy lint, when it falls on open cotton or on picked cotton on the ground or in trucks and trailers. Vehicles used for hauling cotton should not be parked under pecan, cottonwood, sycamore, or other trees from which honeydew may fall. Weeds on which aphid infestations may develop should not be allowed in the cotton fields.

INSECTS IN OR AMONG COTTONSEED IN STORAGE

Cottonseed rarely becomes infested while in storage when proper precautions are followed. Cottonseed or seed cotton should be stored only in a bin or room thoroughly cleaned of all old cottonseed, grain, hay, or other similar products in which insects that attack stored products are likely to develop. Among the insects that cause damage to stored cottonseed or to cottonseed meal are the cigarette beetle (Lasioderma serricorne (F.)), the Mediterranean flour moth (Ephestia kuhniella Zell.), the almond moth (E. cautella (Wlk.)), and the Indian-meal moth (Plodia interpunctella (Hbn.)). Cottonseed that is to be used for planting only may be dusted with toxaphene before being placed in storage. Seed so treated should not be crushed or used for feed.

BIOLOGICAL CONTROL OF COTTON INSECTS

Predators, parasites, and diseases play an important role in the control of insect pests of cotton. Full advantage should be taken of these natural enemies, and the overall pest-control program should include the maximum integration of natural, chemical, and cultural control. To reach this goal there is an urgent need for fundamental studies on the ecology of cotton insects and their enemies and the effect of chemical control upon their relationships. An integrated pest-control program is most likely to reach its greatest efficiency with the expansion of programs such as supervised control. Wherever possible, an attempt should be made to evaluate the role of beneficial insects in the fields being checked.

Among the predaceous insects that are often of value in the control of insects injurious to cotton are several species of ladybird beetles, flower bugs (minute pirate bug), aphis lions (lacewing flies), assassin bugs, the big-eyed bug, praying mantids, predaceous ground beetles, predaceous thrips, predaceous mites, damsel bugs (nabids), ground beetles, larvae of syrphid flies, and certain wasps. Several species of spiders are also predaceous on various cotton insects.

Parasites that are often effective in controlling certain cotton pests include several wasplike species, ranging in size from extremely small ones that develop in aphids and in the eggs of other insects to those the size of some of our common wasps, and several species of tachinid flies that resemble the common house fly.

Thus far the importation and colonization of insect parasites of the pink bollworm and the boll weevil have not proved effective. On the other hand, native predators and parasites are often highly effective against the bollworm, cutworms, spider mites, lygus bugs, whiteflies, and the cotton aphid.

Six species of parasites of the pink bollworm were imported from India in 1953 and 1954, but only five of them--Bracon brevicornis Wesm., B. gelechiae Ashm., Apanteles angeleti Mues., and two species of Chelonus--were reared in sufficient numbers in the laboratory for release. Releases were made in 15 counties in the Brownsville, Port Lavaca, and Eagle Pass areas of Texas, and also in Tamaulipas, Mexico. During this period 405 colonies were released, totaling 698,803 specimens in Texas and 24,483 in Mexico. During 1955 extensive attempts were made to determine if any of these parasites had become established. Although several thousand pink bollworm moths emerged from bolls collected at many liberation points, none of the imported parasites were recovered.

The release of the common ladybird beetles (Hippodamia spp.) has little, if any, practical value in the control of the pink bollworm or other cotton insects. Although they might destroy some eggs or immature stages of other pests, their attack is directed primarily toward aphids. These beetles occur so widely and are so abundant that the few that can be released add little to the local population. There is no evidence that the propagation and release of Trichogramma for bollworm control is of any economic value to the cotton growers.

COTTON-INSECT SURVEYS

The importance of surveys to an overall cotton-insect control program has been clearly demonstrated during the last few years. Surveys conducted on a cooperative basis by State and Federal agencies in most of the major cotton-growing States have developed into a broad, up-to-date advisory service for the guidance of farmers and others associated with cotton production, as well as the chemical industry, which serves the farmers by supplying insecticides. As a result of this survey work, farmers are forewarned of the insect situation and losses are materially reduced below what they would be without the information thus gained. The surveys also help to direct insecticides to areas where supplies are critically needed.

It is recommended that cotton-insect surveys be continued on a permanent basis, that they be expanded to include all cotton-producing States, and that the survey methods be standardized.

It is further recommended that the greatest possible use be made of fall, winter, and early-spring surveys as an index to the potential infestation of next season's crop.

Wherever possible, voluntary cooperators should be enlisted and trained to make field observations and records and to submit reports during the active season.

Each year more people are being employed by business firms, farm operators, and others interested in cotton production to determine cotton-insect populations. It is important that individuals so employed understand the control programs as well as how to make infestation counts. Therefore, State and Federal entomologists should assist in locating and training personnel that have at least some basic knowledge of entomology.

Surveys to detect major insect pests in areas where they have not previously been reported may provide information that can be used in restricting their spread or in planning effective control programs. The survey methods may include (1) visual inspection, (2) use of traps containing aromatic lures, (3) use of light traps, (4) use of mechanical devices such as gin-trash machines, and (5) examination of glass windows installed in air cleaners used in ginning. The methods of making uniform surveys for several of the important insects are described below.

Boll Weevil

Surveys to determine winter survival of the boll weevil are made in a number of States. Counts are made in the fall soon after weevils have entered hibernation and again in the spring before they emerge from winter quarters. A standard sample is 2 square yards of surface woods trash taken from the edge of a field where cotton was grown the previous season. At least five samples are taken from a location.

In the main boll weevil area, population counts are made on seedling cotton to determine the number of weevils entering cotton fields from hibernation quarters. The number per acre is figured by examining the seedling plants on 50 feet of row in each of five representative locations in the field. Additional counts are desirable in large fields. Square examinations are made weekly after the plants are squaring freely or have produced as many as three squares per plant. While walking diagonally across the field pick 100 squares, one-third grown or larger, and an equal number from the top, middle, and lower branches. Do not pick squares from the ground or flared or dried-up squares that are hanging on the plant. The number of squares found to be punctured is the percentage of infestation.

An alternative method is to inspect about 25 squares in each of several locations distributed over the field, the number depending upon the size of the field and the surrounding environment. The percentage of infestation is determined by counting the punctured squares.

In both methods all squares that have egg or feeding punctures should be counted as punctured squares.

Bollworm

Examinations for bollworm eggs on cotton should be started when most of the corn silks in the area begin to dry, or at the time bollworms usually appear, and repeated every 5 days if possible until the crop has matured. While walking diagonally across the field, examine 100 main-stem terminals (the top 3 or 4 inches of the plant) for eggs and worms. If eggs are found on the terminals and 4 or 5 small larvae in the small squares or on the tender top leaves, the infestation is sufficiently heavy to start treatment.

Cotton Aphid

To determine early-season aphid infestations, while walking diagonally across the field make observations on many plants, and record the degree of infestation as follows:

None, if none are observed.
Light, if a few aphids are found on an occasional plant.
Medium, if aphids are present on numerous plants and some of the leaves curl along the edges.
Heavy, if aphids are numerous on most of the plants and the leaves show considerable crinkling and curling.

To determine infestations on fruiting cotton, begin at the margin of the field and, while walking diagonally across it, examine 100 leaves successively from near the bottom, the middle, and the top of the plants. Record the degree of infestation, as follows, according to the average number of aphids estimated per leaf:

None	0
Light	1 to 10
Medium	11 to 25
Heavy	26 or more

Cotton Fleahopper

Weekly inspections should begin as soon as the cotton is old enough to produce squares and be continued until the crop is set and begins to mature. Examine 3 or 4 inches at the top of the main-stem terminal of 100 cotton plants per field, counting both adults and nymphs. Examine three representative points diagonally across a field, 33 terminals approximately 50 feet from each of the two corners and 34 terminals at the center.

Cotton Leafworm

The following levels of leafworm infestation, on the basis of ragging and the number of larvae per plant, are suggested for determining damage:

None, if none are observed.
Light, if 1 or only a few larvae are observed.
Medium, if 2 to 3 leaves are partially destroyed by ragging, with 2 to 5 larvae per plant.
Heavy, if ragging of leaves is extensive, with 6 or more larvae per plant, or if defoliation is complete.

Pink Bollworm

Inspections to determine the degree of infestation in individual fields should be made as follows:

For infestation of blooms: Early in the season, make counts when there is at least one bloom for every 4 or 5 plants, but not more than one for every 2 plants. Walk diagonally across the field and inspect several hundred blooms for those rosetted. Record the number of rosetted blooms on a percentage basis.

For infestation of bolls: While walking diagonally across the field, collect at random 100 green bolls that are hard or firm when pressed. Remove the bracts and calyx of each boll by cutting off a thin slice of the base; cut each section midway between the sutures so that each lock can be removed intact; examine the inside of the carpel for the characteristic tunnels or mines made by the young larvae. The number of bolls found infested represents the percentage of infestation.

Other inspection techniques: There are other inspection methods that are helpful in directing control activities against the pink bollworm. They make possible the detection of infestations in previously uninfested areas and the evaluation of increases or decreases as they occur in infested areas. They are also used to determine the population of larvae in hibernation and their carryover to infest the new cotton crop.

1. Inspection of gin trash: Procure freshly ginned "first cleaner" trash, which has not been passed through a fan, from as many gins as possible in the area. Maintain the identity of each sample and separate mechanically all portions of the trash larger and all portions lighter in weight than the pink bollworm. A small residue is left which must be examined by hand. This method is very efficient for detecting the presence and abundance of the pink bollworm in any given area, but it does not usually reveal the exact field or the percentage of infestation.

2. Inspection of lint cleaner: During the ginning process the free larvae remaining in the lint are separated in the lint cleaners, and a substantial number of them are thrown and stuck on the glass inspection plates. All the larvae recovered are dead. For constant examination at a single gin, wipe off the plates and examine after each bale is ginned. In this way the individual field that is infested may be determined. For general survey, make periodic examinations to detect the presence of the pink bollworm in a general area.
3. Examination of debris: Between January and the time squares begin to form in the new crop, examine old bolls or parts of bolls from the soil surface in known infested fields. Examine the equivalent of 100 bolls and count the living larvae. From these data the number of larvae remaining in hibernation at any given date may be determined. Such records when maintained from year to year provide comparative data which may be used in determining appropriate control measures.
4. Use of light traps: Especially designed traps containing mercury-vapor or blacklight fluorescent bulbs will attract pink bollworm moths. Such traps have been used to discover new infestations, and their usefulness and value for survey work should be fully explored.

Spider Mites

While walking diagonally across the field examine 100 or more leaves taken successively from near the bottom, the middle, and the top of the plants. Record the degree of infestation as follows, according to the average number of adult females per leaf:

None	0
Light	1 to 10
Medium	11 to 25
Heavy	26 to 100
Very heavy . . .	More than 100

Thrips

While walking diagonally across the field, observe or inspect numerous plants, and record the damage as follows:

None, if no thrips or damage if found.
Light, if newest unfolding leaves show only a slight brownish tinge along the edges with no silvering of the underside of these or older leaves, and only an occasional thrips is seen.

Medium, if newest leaves show considerable browning along the edges and some silvering on the underside of most leaves, and thrips are found readily.
Heavy, if silvering of leaves is readily noticeable, terminal buds show injury, general appearance of plant is ragged and deformed, and thrips are numerous.

Predators

Predator populations may be estimated by counting those seen while examining leaves, terminals, and squares for pest insects.

SUPERVISED CONTROL

Supervised control--a system of field scouting and supervision that has been used for over 30 years--has been increasing in importance in some of the Cotton States. Fields are scouted at least weekly by unbiased and specially trained personnel, and control measures are recommended when necessary. Supervised control makes possible more accurate timing of insecticide applications and helps to eliminate needless treatments. Furthermore, it permits better advantage to be taken of natural and cultural controls. Many farmers have used insecticides unnecessarily because of inadequate information on the presence of destructive insects, and sometimes the treatments have been harmful to beneficial insects. Since the potentially destructive populations may be located before they have had a chance to do any damage, timing of control measures is as nearly perfect as practically feasible. Every recommendation is specific for each individual field, and all the factors involved are considered before any recommendations are made.

EXTENSION EDUCATIONAL PROGRAM FOR NEXT YEAR

There is a great need for a continuation of the strong educational program that will present the facts concerning cotton-insect control. This program should be conducted in such a way as to reach everyone interested in cotton production. Growers especially need these facts to help them in making plans for the next crop.

To avoid confusion, recommendations must be basically the same in areas where the insect problems are similar. Points upon which agreement must be reached are (1) the insecticides that are effective, economical, and safe to use with proper precautions, (2) the time to start treatment, (3) the rate of application, (4) the interval between applications, and (5) how to apply the insecticides.

To facilitate the production of the next crop of cotton, well in advance of planting the crop the Extension Service should strengthen and intensify its educational work on the seven-step cotton-production program. To help accomplish the goal each State should have the following committees: (1) A State-wide cotton-production committee made up of representatives from all agencies and organized groups within the State, to help develop, promote, and provide leadership to the program; (2) a technical committee representing all State and Federal agricultural agencies, to prepare recommendations on cotton production and insect control; (3) an extension committee selected by the State director, which will be responsible for the educational program. Each county or parish should be organized on a basis somewhat comparable to that of the State.

Experience has shown that such committees play an important part in the planning and carrying out of an integrated program in which all agencies and segments of industry can cooperate to keep growers informed of the need for insect control and industry of the need for insecticides.

The extension program will stress teaching growers to examine each field at least once a week to determine the degree of infestation. Since the county agent is a teacher, extension entomologists should see that agents understand the importance of this work. The behavior of the insect and the cotton plants in relation to recommendations should be pointed out to growers to help them to evaluate their findings in order to prevent waste of insecticides.

The extension program and supervised control should be closely coordinated. Prompt and full use should be made of data furnished by "scouts" and survey entomologists, and a close working relationship should be maintained.

The following steps outline the extension program that will be carried out in varying degrees in the Cotton States:

Winter

1. Hold State or area meetings with insecticide suppliers and applicators.
2. Hold district meetings with county agents and farm leaders.
3. Through general county meetings, press and radio releases, circular letters, and posters, stress the control program. Also encourage growers to arrange for the purchase of insecticides and to get equipment in shape for next season.
4. Secure the cooperation of farm-loan agencies, oil mills, ginners, fertilizer associations, and other groups concerned with the production of cotton.

Spring

1. Release information from surveys by State and Federal entomologists on boll weevil survival.
2. Continue meetings on cotton-insect control.
3. Demonstrate procedure for making counts to determine when and where early boll weevil control is needed.
4. Issue recommendations on early-season control.
5. Conduct 4-H Club and other youth meetings devoted to cotton insects and their control.

Summer

1. Release information on insect infestation.
2. Make field demonstrations on insect identification, infestation counts, and proper application of insecticides.
3. Issue timely radio programs, newspaper articles, and circular letters on insect conditions and control.
4. Make field tours to study demonstrations and experiments on cotton-insect control.
5. Utilize daily radio reports on weather conditions.

Fall

1. Stress importance of defoliation in preventing insect damage to young bolls.
2. Promote an early stalk-destruction program to reduce insect populations in areas where this is feasible.

Educational Tools

Make full use of the following educational tools to stimulate the adoption of recommended practices:

1. Publications--yearly recommendations.
   a. Plan of organizational set-up showing responsibility of each agency.
   b. Guides or recommendations for controlling cotton insects.
2. Mimeographed informational material.
3. Posters, charts, exhibits at fairs, models.
4. Magazine articles.
5. Cotton or other circular letters.
6. Newspaper publicity, special editions.
7. Radio spot announcements and recordings. Sponsored program at set time and day each week to build up an audience for the program.

8. Public meetings.
9. Individual contacts.
10. Slides and motion pictures.
11. Television where available.
12. Equipment displays at method demonstrations.
13. Result demonstrations.
14. Visits to experiment stations.

NEEDED RESEARCH

Additional information is needed on many phases of cotton-insect control to make it more effective and economical. Certain problems are so acute as to demand vigorous attack immediately, if the cotton industry is to be protected against heavy insect losses. It is therefore urged that all those concerned with cotton insects concentrate their efforts on these urgent problems and attempt to secure more adequate support for this research. The following lines of research are of prime importance:

(1) Basic and Applied Research on Resistance of Insects to Insecticides, Particularly with Reference to the Boll Weevil. This research involves (a) determination if resistance to recommended insecticides already exists among important cotton insects; (b) determination of mortality curves with insecticides in use or promising for future use in several localities across the Cotton Belt, to serve as a basis of comparison in the future; (c) determination of influence of season, food, climate, insect age and activity, and other factors on susceptibility of insects to insecticides; (d) basic research on insect physiology in relation to standard and new insecticides.

(2) Development of New Insecticides. The need for additional insecticides, particularly those having different modes of action, to control several cotton pests is obvious. This need is emphasized by the appearance of resistance among boll weevils and other cotton insects in certain areas. Plot and field tests of such materials as Bayer 17147 and Am. Cyanamid 3911 against many pests and across the Cotton Belt are needed.

(3) Toxicological and Residue Studies. Adequate information on the toxicity of the new insecticides to higher animals and on the amount and persistence of residues is necessary to make such materials available for safe use. All entomologists should cooperate with chemists and toxicologists in gathering such information.

(4) Systemic Insecticides. Research to develop new and evaluate presently available promising materials is urged. Systemic insecticides have the advantage of being relatively innocuous to beneficial insects, including honey bees, which permits their full utilization by the farmer. The question of residues in cottonseed and their effect on germination, plant growth, and fruiting need continuous study.

(5) Timing of Insecticide Applications. The timing of applications needs continuing attention, but it is doubtful whether sufficient attention has been given to when to start and stop applications. All agree that insecticides should not be used unless needed, but there is a lack of criteria on which the farmer, or even the entomologist, can always determine when their use is economically sound. This difficulty is especially apparent in control of the pink bollworm, boll weevil, and bollworm. Such research is needed to develop criteria to serve as a guide with reference to control of a pest by biological agents, and to evaluate plant growth, crop potentials, and probable production gains in relation to the use of insecticides.

(6) Research on Diseases of Insects. Too little attention has been paid to the possibility of using pathogens in cotton-insect control. It has been demonstrated that disease can be successfully employed against the alfalfa caterpillar, sawflies, and the Japanese beetle. Many cotton pests are killed by diseases, but more research is needed on the identity of the organisms and how they might be used in control operations. The use of diseases in insect control does not interfere with the operation of parasites, predators, or bees and might help meet the resistance and residue problems.

(7) Relation of Irrigation and Fertilizers to Cotton-Insect Control. Irrigation creates a favorable environment for the maximum growth, fruiting, and yield of the cotton plant, and greatly increases its response to the use of fertilizer. At the same time it creates a highly favorable environment for some of the cotton insects.

The recent rapid expansion of irrigation in the humid South has made conditions more favorable for the boll weevil, bollworm, and pink bollworm. It is urgent that the ecology of these pests and the schedules of insecticide applications be re-examined under irrigated conditions. It is also urgent that irrigation schedules in all areas, particularly late-season irrigation, be studied carefully in relation to insect development and control.

Increased fertility due to heavy use of fertilizers or growth of legume crops, with or without irrigation, creates more favorable conditions for many insect pests and demands that more attention be given to the timing of insecticide applications. Studies are needed to determine the economic feasibility of using extremely high rates of fertilizer in areas where insect pests may be unusually severe.

(8) Effect of Insects on Cotton Quality. Buyers and spinners are giving increased attention to cotton quality. This is being reflected in prices paid the farmer. It is important, therefore, that the effect of insect attack on the quality of lint and seed be fully evaluated. The effect of control measures on the quality of the crop must also be known.

Preliminary information indicates that considerable losses are sustained from the effect of insect infestations on fiber color, maturity,

fineness, and strength; seed weight and oil content are also lowered. The effect of boll rots induced or promoted by insect attack should also be studied.

It is urged that workers conducting tests of insecticides measure ling and seed quality as well as yield. They should also study the effect of different degrees of insect infestation on quality.

(9) Development of Improved Cotton Varieties. Cotton varieties that grow tall and rank under conditions of adequate or excessive moisture intensify entomological problems, particularly those of insecticide application. Cotton breeders are urged to continue and perhaps expand research in developing varieties of improved growth habits under these conditions.

(10) Stalk Shredders. The disposal of crop residues is an important factor in the control of the boll weevil and the pink bollworm. This practice will control both pests in areas where cotton can be harvested and the crop residue destroyed well in advance of the frost date. For the pink bollworm complete shredding or crushing of infested bolls is essential, but for the boll weevil the elimination of immature fruiting forms as early as possible before frost is effective.

Research is needed to develop more efficient and economical machines for crop-residue disposal. Strippers, shredders, crushers, or machines combining these operations offer exceptional promise for reducing the winter survival of pink bollworms. A greatly intensified cooperative effort should be initiated to make more effective machines available as soon as possible.

(11) Equipment for Applying Insecticides.

(a) On small farms. Satisfactory equipment is not available for applying insecticides to cotton on farms of 5 to 15 acres. Hand equipment requires too much labor and often does not give satisfactory distribution. Aerial application of insecticides is usually not practical on small farms. Heavy tractor equipment often cannot be employed during wet weather or following irrigation; besides, in some areas tractors are not yet generally available on small farms. Research by various agencies including industry should be stepped up to develop small light power equipment or mule drawn equipment for use on small farms.

(b) On larger farms. More suitable equipment for applying insecticides with ground machines during wet weather or following irrigation, especially when cotton has reached rank growth, is urgently needed. Research to develop such equipment should be stepped up.

Increased research on many other important phases of cotton-insect control is needed. Some of these needs follow:

(a) Ecological studies on all cotton pests, including the interrelation of these pests, and the effect of parasites, predators, climatic conditions, plant-soil relations, and cultural, insecticidal, and other control methods.
(b) Studies of the finer points in the biology of the more important insects and mites; for example, determination of the mating habits of the pink bollworm to see whether there is a possibility of control by sterilization of the moths by the use of gamma or other rays.
(c) Studies of migration of important cotton insects.
(d) Insecticide research, including mode of action, timing of applications, the development of resistance among parasites and predators, the relative susceptibility of important parasites and predators to various insecticides, and the effects of insecticides on soils and various crops grown in rotation with heavily treated cotton.
(e) Studies of the relation of chemical defoliation and plant desiccation to various pests.
(f) Improved methods of survey and the assembly of information to permit the forecasting of insect outbreaks and damage.
(g) Fundamental studies on the anatomy and physiology of the important cotton pests.
(h) Investigation of the effect of ginning and oil-mill equipment on the pink bollworm and the devising of improved equipment.
(i) The discovery and development of cottons resistant to attack by pest insects.
(j) Studies on the nutritional requirements of insects and techniques in handling so as to develop methods of colonizing species and thus facilitate research along many lines.
(k) Studies on nutritional requirements of insects as an aid to developing new concepts of control.

CONFEREES AT NINTH ANNUAL CONFERENCE

One hundred and sixteen entomologists and associated technical workers concerned with cotton-insect research and control participated in this conference. They were from the agricultural experiment stations, extension services, and other agencies in 16 cotton-growing States, Puerto Rico, the United States Department of Agriculture, and the National Cotton Council of America. The statements in this report were agreed upon and adopted by the following conferees:

Alabama

F. S. Arant, Head, Dept. Zoology and Entomology, A.P.I., Auburn
T. E. Corley, Assoc. Agricultural Engineer, A.P.I., Auburn
James A. Griffin, Asst. Entomologist, Agr. Expt. Sta., Auburn
R. L. Robertson, Asst. Entomologist, A.P.I., Auburn
W. A. Ruffin, Ext. Entomologist, A.P.I., Auburn
A. L. Smith, Plant Pathologist, A.P.I., Auburn

Arkansas

Gordon Barnes, Ext. Entomologist, Univ. Arkansas, Fayetteville
T. F. Leigh, Dept. Entomology, Univ. Arkansas, Fayetteville
Charles Lincoln, Head, Dept. Entomology, Univ. Arkansas, Fayetteville
L. O. Warren, Survey Entomologist, Univ. Arkansas, Fayetteville
John W. White, Assoc. Dir., Agr. Expt. Sta., Fayetteville

California

Marvin Hoover, Cotton Specialist, Univ. California, Rt. 1, Box 17, Shafter
H. T. Reynolds, Entomologist, Univ. California, Citrus Expt. Sta., Riverside

Florida

W. C. Rhoades, Entomologist in Charge, North Fla. Expt. Sta., Quincy

Georgia

C. M. Beckham, Chairman, Div. Entomology, Agr. Expt. Sta., Experiment
C. R. Jordan, Ext. Entomologist, Univ. Georgia, Athens
L. W. Morgan, Asst. Entomologist, Coastal Plain Expt. Sta., Tifton
W. H. Sell, Ext. Agronomist, Cotton, Univ. Georgia, Athens

Illinois

George C. Decker, Head, Section of Economic Entomology Illinois Natural History Survey, Urbana

Kansas

Perry L. Adkisson, Graduate Asst. in Stored Products Insects, Kansas State College, Manhattan
George W. Ware, Graduate Asst. in Toxicology, Kansas State College, Manhattan

Louisiana

James R. Brazzel, Asst. Entomologist, Agr. Expt. Sta., Baton Rouge
Dan F. Clower, Asst. Entomologist, Agr. Expt. Sta., Baton Rouge
Kirby L. Cockerham, Ext. Entomologist, L.S.U., Baton Rouge
Woody Dry, Asst. Ext. Entomologist, L.S.U., Baton Rouge
L. D. Newsom, Head, Ent. Research, Agr. Expt. Sta., L.S.U., Baton Rouge
John S. Roussel, Assoc. Entomologist, Agr. Expt. Sta., Baton Rouge
L. W. Sloane, Asst. Agronomist, Northeast La. Expt. Sta., St. Joseph
C. E. Smith, State Entomologist, Capitol Bldg., Baton Rouge

Mississippi

A. G. Bennett, Ext. Entomologist, State College
L. B. Davis, Inspector, State Plant Board, Leland
N. L. Douglass, Inspector, State Plant Board, Grenada
W. L. Giles, Superintendent, Delta Branch Expt. Sta., Stoneville
A. W. Goza, Asst. Entomologist, Agr. Expt. Sta., State College
O. T. Guice, Jr., General Inspector, State Plant Board, State College
A. L. Hamner, Assoc. Entomologist, Agr. Expt. Sta., State College
W. B. Harbour, Asst. Ext. Agricultural Engineer, Stoneville
Charles E. King, Entomologist, Delta Branch Expt. Sta., Stoneville
Clay Lyle, Dean and Director, Div. of Agr., Miss. State College, State College
John L. McVey, Asst. Ext. Agricultural Engineer, State College
F. A. Smith, Inspector, State Plant Board, Senatobia
T. M. Waller, Agronomist, Extension Service, State College
C. A. Wilson, Asst. Prof., Dept. Zoology and Entomology, State College
B. J. Young, Collaborator, 149 N. Hinds, Greenville
David F. Young, Jr., Asst. Ext. Entomologist, State College

Missouri

Lee Jenkins, Assoc. Prof. of Entomology, Univ. Missouri, Columbia
Stirling Kyd, Ext. Entomologist, Univ. Missouri, Columbia
George W. Thomas, Survey Entomologist, Univ. Missouri, Columbia
A. J. Williams, Asst. Prof. Entomology, 710 Montgomery St., Sikeston

North Carolina

Walter J. Mistric, Jr., Cotton Entomologist, State College, Raleigh

Oklahoma

D. E. Bryan, Entomologist, A. & M. College, Stillwater
C. F. Stiles, Ext. Entomologist, A. & M. College, Stillwater

Puerto Rico

Mario E. Perez, Agr. Expt. Sta., Rio Piedras

South Carolina

C. H. Arndt, Plant Pathologist, Agr. Expt. Sta., Clemson
James H. Cochran, Head, Dept. Entomology and Zoology, Clemson College, Clemson
W. C. Nettles, Leader, Ext. Entomology and Plant Disease Work, Clemson
John K. Reed, Assoc. Entomologist, Agr. Expt. Sta., Clemson
L. M. Sparks, Ext. Specialist, Cotton Insects and Diseases, Clemson

Tennessee

H. L. Bruer, Dir. Entomology and Plant Pathology, Dept. of Agr., 410 State Office Bldg., Nashville
John A. Hammett, Dept. of Agr., Memphis
James H. Locke, Dept. of Agr., Memphis
R. P. Mullett, Ext. Entomologist, Univ. Tennessee, Knoxville
W. W. Stanley, Entomologist, Agr. Expt. Sta., Knoxville

Texas

James A. Deer, Ext. Service, Agr. Expt. Sta. Weslaco
Fred C. Elliott, Ext. Cotton Work Specialist, College Station
F. M. Fuller, Jr., Ext. Entomologist, College Station
J. C. Gaines, Head, Dept. Entomology, A. & M. College, College Station
R. D. Lewis, Dir., Agr. Expt. Sta., College Station
Dial F. Martin, Prof. of Entomology, Agr. Expt. Sta., College Station
C. B. Spencer, Chairman, Cotton Production Committee of Statewide Cotton Committee of Texas, 624 Wilson Bldg., Dallas
George P. Wene, Agr. Expt. Sta., Weslaco

Virginia

M. P. Lacy, Assoc. Ext. Agronomist, Va. Polytechnic Inst., Blacksburg

U. S. D. A., Agricultural Research Service

H. L. Haller, Asst. Director, Crops Research, Washington 25, D. C.

Entomology Research Branch

E. F. Knipling, Chief of Branch, Beltsville, Md.
F. C. Bishopp (Retired), 8014 Piney Branch Road, Silver Spring, Md.
R. W. Harned (Retired), 4417 Garfield St., N.W., Washington 7, D.C.
E. W. Dunnam (Retired), 402 Feltus Blvd., Leland, Miss.

Cotton Insects Section

K. P. Ewing, Head, Beltsville, Md.
C. F. Rainwater, Assistant Head, Beltsville, Md.
T. P. Cassidy, Port Lavaca, Tex.
A. J. Chapman, Brownsville, Tex.
R. E. Furr, Leland, Miss.

U. S. D. A., Agricultural Research Service

Entomology Research Branch

Cotton Insects Section--continued

R. E. Fye, Leland, Miss.
R. C. Gaines, Tallulah, La.
S. E. Jones, Brownsville, Tex.
M. E. Merkl, Leland, Miss.
C. R. Parencia, Waco, Tex.
T. R. Pfrimmer, Tallulah, La.
C. A. Richmond, Brownsville, Tex.
A. L. Scales, College Station, Tex.
G. L. Smith, Port Lavaca, Tex.
W. A. Stevenson, Tucson, Ariz.
R. L. Walker, Florence, S. C.

Plant Pest Control Branch

L. F. Curl, Asst. Chief of Branch, Washington 25, D. C.
H. L. Alford, Pink Bollworm Control Project, Alexandria, La.
N. O. Berry, Mexican Fruit Fly and Citrus Blackfly Project, Harlingen, Tex.
J. I. Cowger, Economic Insect Survey Section, Gulfport, Miss.
Kelvin Dorward, Head, Economic Insect Survey Section, Washington 25, D.C.
C. C. Fancher, Southeastern Plant Pest Control Region, Gulfport, Miss.
John M. Landrum, Grasshopper Control Project, Waco, Tex.
D. M. McEachern, Pink Bollworm Control Project, San Antonio 6, Tex.
R. W. White, Pink Bollworm Control Project, San Antonio 6, Tex.

Field Crops Research Branch

M. G. Weiss, Chief of Branch, Beltsville, Md.
Joseph Hacskaylo, Plant Physiologist, Cotton and Other Fiber Crops Section, College Station, Tex.
P. B. Marsh, Plant Physiologist, Cotton and Other Fiber Crops Section, Beltsville, Md.
M. W. Parker, Head, Weed Investigations Section, Beltsville, Md.
J. T. Presley, Pathologist, Cotton and Other Fiber Crops Section, Beltsville, Md.
W. H. Tharp, Plant Physiologist, Cotton and Other Fiber Crops Section, Beltsville, Md.

State Experiment Stations Division

E. R. McGovran, Entomologist, Washington 25, D. C.

Federal Extension Service

M. P. Jones, Entomologist, Washington 25, D. C.
J. M. Saunders, Ext. Agronomist, Washington 25, D. C.

Commodity Stabilization Service

H. H. Shepard, Food and Materials Requirements Div., Washington 25, D. C.

National Cotton Council of America, Production and Marketing Division, P. O. Box 9905, Memphis 12, Tenn.

Claude L. Welch, Director
H. G. Johnston, Head, Research and Development
J. Ritchie Smith, Head, Educational Services
James A. Davis, Educational Specialist

☆ U. S. GOVERNMENT PRINTING OFFICE: 1956 O— 376082